Investment Planning Service

Phototypesetting Industry

Creative Strategies Incorporated

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July 1970

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THE PHOTOTYPESETTING INDUSTRY IN BRIEF

The phototypesetting industry has experienced dynamic growth during the past several years. It is expected to grow at a compound annual rate of 20 percent through 1975, increasing in size from $49 million in 1969 to almost $150 million in 1975.

The rapid increase in demand for phototypesetters can be attributed to several key factors:

- The increased use of computers for typesetting composition work.
- The increased use of existing computer data banks to reprint material in a condensed or varied format.
- The rapid growth of the offset printing process.
- The penetration of new markets by low-priced text-oriented phototypesetters and medium-priced cathode ray tube (CRT) phototypesetters.

The phototypesetting industry, as a segment of the typesetting industry, is experiencing revolutionary change. Introduction of electronic technology into the typesetting process has caused repercussions in major sectors of the industry, such as: (1) the structure of the major labor union, (2) the hardware orientation of most major manufacturers, and (3) the artistic freedom enjoyed by authors. The typesetting process is comprised of the following components: (1) entry keyboards, (2) computer processors, (3) typesetters using either hot metal linecasting, phototypesetting, or strike-on typesetting, and (4) consumables. This report studies in depth the phototypesetting industry.

Second Generation Phototypesetters

Second generation phototypesetters produce typeset copy from master character sets stored photographically within the machine. They are generally operated from perforated paper tape but may use direct entry from a keyboard or magnetic tape input. A series of lenses, mirrors and apertures selects the desired character image, projects it along the optical path, and magnifies or reduces it to a specific size for exposure on the output media, a sensitized film or paper.

The initial second generation phototypesetters were developed during the 1950's. In general, the initial devices were primarily concerned with typographic flexibility and high-quality output. Output speeds, while faster than hot metal linecasters, were of secondary importance.

During the last several years a proliferation of new machines has entered the market, greatly expanding the selection of capabilities available to a potential user. The variety of machines now available ranges from $4,500 text-oriented phototypesetters to $70,000 all-purpose units with very large on-line font libraries. Output speeds of 10 newspaper lines per minute (lpm) that were typical of early second generation devices have now increased to a normal range of 25 to 40 lpm, with some recently announced machines specifying a speed of 200 lpm.

The effect of a broader selection of equipment capabilities and prices has been an expansion and restructuring of the market. Low-priced (under $15,000) text-oriented phototypesetters are replacing the strike-on typesetting process in many operations producing primarily book or newspaper text

in a fairly rigid format. This is a new market segment that was not in existence until Compugraphic introduced its line of inexpensive phototypesetters in 1968. Another new market segment has resulted from the recent introduction of a group of machines that exhibit capabilities between those of the traditional medium-priced all-purpose machines and those of the new inexpensive text devices. These hybrid units are priced between $15,000 and $30,000. They are capable of doing limited display work and most units can automatically mix several fonts and type sizes under control of the input tape.

Creative Strategies, Incorporated (CSI) forecasts that the total market for second generation phototypesetters will experience a 20 percent compound annual growth in sales value of units shipped during the period 1969-1975. The market, estimated at $35 million in 1969, should increase to $103 million by 1975.

Growth of individual market segments is expected to differ significantly from the overall rate of 20 percent. CSI forecasts that the sales value of units shipped in each market segment will experience compound annual growth during the period 1969-1975 as follows: (1) low-priced text machines—45 percent, (2) low-priced hybrid or versatile machines—23 percent, and (3) medium-priced typographic machines—12 percent.

Third Generation Phototypesetters

Third generation CRT phototypesetters produce typeset copy by means of electronic selection and exposure of character images on the face of a CRT. All units operate from computer-generated magnetic tape except the Mergenthaler Linotron 505 that uses paper tape as its primary input source. Character images are stored photographically or digitally within the machine, projected on the face of a display CRT, and focused on the output media by a simple lens.

CRT phototypesetters are divided into two distinct market segments, high-priced fully electronic units and medium-priced electronically controlled devices. The high-priced all electronic units were developed around 1965. They are powerful machines that possess output speeds from 10 to 40 times as great as most second generation phototypesetters. The typographic capability of these CRT devices is extensive as they have the ability to automatically change the size or shape of a character. That is, the character can be electronically slanted to simulate italics, stretched or flattened to vary its height within the same character width, or changed in other similar ways. Both the RCA Videocomp and Harris-Intertype Fototronic CRT have the optional ability to produce output on microfilm as well as the standard phototypesetting film and paper.

CRT phototypesetters are expensive machines costing from $350,000 to $500,000 depending on the number of options chosen. As a result, each manufacturer uses a rental or lease program as an integral part of its marketing strategy. All manufacturers now stress a total systems approach to assist users in maximizing the effectiveness of the phototypesetter within the computer typesetting system. RCA has much stronger systems capabilities than Harris-Intertype or Mergenthaler because of past experience in the computer field.

A second market segment has developed with introduction of the Mergenthaler Linotron 505 in 1967. The device is an electronically controlled CRT phototypesetter that combines mechanical and electronic subsystems in an inexpensive configuration. The speed and flexibility of the unit is significantly less than those of the purely electronic CRT units, but a price of $125,000 has made the Linotron 505 quite attractive to a segment of users who are too small to justify the cost of the more powerful CRT phototypesetters.

The Linotron 505 is currently the only machine serving this market segment although IBM, Photon, Harris-Intertype, and possibly Xerox have developed or are developing units thought to be directed toward this segment. CSI anticipates that one or two additional machines will be competing with the Linotron 505 for this market segment within the next several years.

CSI forecasts that the total market for third generation phototypesetters will grow from $14 million in 1969 to $43 million in 1975. This 21 percent compound growth rate for all CRT devices is made

up of an expected rate of 38 percent for the medium priced units and only 9 percent for the large, expensive machines. Growth in the sales of large CRT units will be slow because a tremendous production volume is required to cover the cost of the phototypesetter and its host computer. Many industry observers feel that the current market is already over-saturated but will continue to grow as increased use of existing data banks makes more applications economically feasible.

Companies

The current market leader is Photon, Incorporated. The company presents the broadest product line in the phototypesetting industry. It competes primarily in the medium-priced typographic market segment but also participates in the low-priced versatile or hybrid market through its own 713-Taskmaster and the AM 725 which it manufactures for VariTyper. Possibly Photon's most exciting product is the newly announced Model 7700, a typographic computer peripheral printer. CSI forecasts that the company will maintain its strong position as the market leader and attain approximately 26 percent of the total market with sales of $39 million by 1975. Anticipated acceptance of the Model 7700 and a continued dominance of the medium-priced typographic market segment will provide most of the company's growth.

Mergenthaler is the second most important factor in the phototypesetting market and is expected to maintain that position through 1975. By 1973, Mergenthaler is expected to hold almost 21 percent of the total market; however, unless the company introduces new products or revises the Linotron 505, increased competition for the 505 is expected to drop the company's market share to 15 percent in 1975. Mergenthaler enjoys a strong loyalty within the industry, a phenomenon that generates rapid market acceptance for most of the company's new products. The Linotron 505 and the newly announced V-I-P should provide most of Mergenthaler's strength over the next five years.

Compugraphic is one of the most successful ventures in phototypesetting. Since introduction of a series of inexpensive text-oriented phototypesetters in 1968, the company has gained leadership in the number of units sold annually. By 1975, sales of existing products plus the newly announced ACM 9000 series should capture 10 percent of the market for Compugraphic.

Other companies that can be expected to capture a sizeable share of the market are Harris-Intertype, RCA, and Star Parts. Other manufacturers that will attain varying degrees of success throughout the period 1969-1975 are VariTyper, Fairchild Graphic Equipment Division of Fairchild Camera and Instrument Corporation, and the Friden Division of the Singer Company. The phototypesetting industry is quite volatile at present and the introduction of new products or other changes could significantly alter existing relationships and competitive positions.

1 THE TYPESETTING INDUSTRY

Background

Printing is a centuries-old craft that evolved through the mechanization of the nineteenth century and is now adapting to the new electronic technologies. When Johannes Gutenberg invented proportionally spaced movable type around 1450 A.D., the letterpress process (described in the insert on printing techniques) was already well established. Although refined and improved, this process was the only one available until the twentieth century when both the gravure and offset lithographic printing techniques were developed. Letterpress is still used extensively in newspaper, quality-book and magazine publishing. Gravure's primary applications have been in the commercial printing of catalogues and containers. Offset lithography is rapidly establishing itself in all sectors of the printing industry, accounting for more than 50 per cent of all printing done in the United States, primarily because master plates can be made more cheaply and quickly than for letterpress or gravure.

The typesetting industry as part of the printing industry has evolved in a similar manner. Typesetting was performed by hand until Ottmar Mergenthaler developed a mechanical typesetting machine, the Linotype, in 1885. The Linotype (described briefly in the insert on printing techniques) was a hot metal linecasting machine that greatly increased the speed of typesetting. After World War II, development of phototypesetters again increased the efficiency of the typesetting process and enhanced commercial refinement of of the offset printing process.

Today's Industry

The typesetting industry is presently experiencing technological change with a rapidity it has never before encountered. The introduction of electronic technologies has strengthened the industry while simultaneously forming the foundation for new industries which will become formidable competitors in the future.

The participants within the typesetting industry are slowly beginning to realize that they are no longer solely in the printing and publishing industry which they understand, but are now part of the much larger, more complex information or communications industry which they do not fully understand. Much of the impetus for change is no longer under their control but is centered outside the field of typesetting in the hands of experts who understand the application and impact of computer and computer-related technologies.

The impact of these events on the industry is profound and the industry is particularly chaotic during the current transition phase. Several of the major transitional problems buffeting the industry are described below.

- The principal labor union involved, the International Typographical Union, has publicly pledged itself to a program of upgrading the skills of its members to the programming and technical levels required for computer application. In fact, the program has enjoyed little true support or success and the union has stood as a major obstacle to the installation of computerized typesetting.

- Manufacturers of phototypesetting machines are accustomed to selling hardware and not systems. Once a machine is installed, manufacturers are not giving the user adequate soft-

PRINTING TECHNIQUES

Three primary techniques are currently used for printing. Each technique uses wet ink to transfer the image from printing plate to the final viewing surface, but differ in the method of application.

Letterpress

The letterpress process uses printing plates with raised character images that receive the ink and are pressed directly against the surface to be printed. The plates are normally cast or molded metal but can be molded rubber for low-quality applications. The making of metal plates is both time consuming and costly. Due to the cost of plate making, the primary applications for letterpress are high volume production runs—i.e., for newspapers and magazines—and high-quality book work.

The making of letterpress printing plates is most economically suited to hot metal typesetting. The output from this process is a line of raised type, called a slug, that is cast from molten lead into recessed character molds. The relief elements from the linecasting slugs are ready for plate molding without additional processing. Film or paper output from a phototypesetter must be mechanically engraved or etched to prepare relief elements before molding may take place.

Gravure

In the gravure process, the character image is cut or etched into the plate in a pattern of tiny sunken wells that hold the ink. Transfer occurs when the inked plate is pressed directly against the surface to be printed. Color intensity can be varied by changing the cubic volumes of individual ink wells. The gravure process is well adapted to the output from phototypesetters because it uses photographic positives (normal output from most phototypesetters) to prepare the inking plates.

Lithography

The lithographic process uses chemically formed patterns for image transfer. The printing and nonprinting areas of the lithographic plate are in virtually the same plane. The character images to be printed are made receptive to greasy ink while the blank or "white" spaces are made receptive to water. As the plate is alternately brought into contact with water and ink, the water repels the ink except in the area to be printed. Printing can occur by one of two methods. In direct lithography the plate is pressed directly against the surface to be printed. In offset lithography the plate is pressed onto a blanket which is then pressed against the viewing surface. It is the offset process which is most widely used in the printing industry.

Phototypesetting, which produces character images on sensitized film or paper, and strike-on typesetting, which uses a typewriter to make direct impressions on paper, are used extensively with offset lithography because the printing plates can be made economically either by photographic exposure or by direct typewriter imaging. Lithographic plates are made more cheaply and quickly than either letterpress or gravure plates but have not been reliable for long run applications. The primary advantages of the offset lithography process over the letterpress process are: (1) significantly lower press costs, (2) lower plate costs, and (3) shorter plate preparation time.

ware support. As a result, inefficient use of existing units makes effective competition against other information and communications media more difficult.

- Technologists who are dedicated to ultimate efficiency of the computer typesetting system and writers and authors who have hitherto enjoyed a great deal of artistic freedom have found the formation of a working relationship to be a complex task. Compromise solutions are slowly taking effect as each extreme better understands the other, but a long term solution has yet to evolve.

Typesetting Process Components

The composition or typesetting process involves the conversion of the material to be printed into the desired printing format. The process as it exists today is shown in Figure 1. The major components that constitute a typesetting system include: (1) an entry keyboard, (2) computer processor, (3) typesetter, using either a hot metal, photomechanical, electronic or strike-on technique, and (4) consumables. A description and discussion of each component follows.

Entry Keyboard

Keyboard entry is the primary input medium for the typesetting process. Initially keyboards were used for direct input into hot metal linecasters and later into some phototypesetters. Presently, they are primarily used to control perforators that prepare punched paper tape, but are finding increased use with magnetic tape encoders to prepare tapes directly for computer use.

Most phototypesetter manufacturers produce or at least market keyboards which are designed especially for their devices. Other manufacturers also produce keyboards, often under OEM contract. Nonjustifying (ragged right edge) keyboards range in price from $2,000 to $5,000 with most less than $3,000. Justifying keyboards are more expensive, ranging from $2,800 to $15,000 with the majority costing less than $7,500. Magnetic tape encoders are priced above $10,000 and are nonjustifying devices.

As is typical with computerized systems, keyboard entry is one of the principal bottlenecks and economic deterrents to computer typesetting. The typical rate of input for present keyboards is 5 to 6 characters per second. For the new cathode ray tube (CRT) phototypesetters and associated medium scale computers, over 100 keyboards are required to keep the system fully occupied. While work is being done to improve keyboard layouts and operator training and to perfect shorthand techniques, it is obvious that input systems depending on hardware capabilities rather than human capabilities are increasingly in demand. Technical and economic improvements in optical and voice recognition techniques are expected to provide much of the required solution.

Computer Processors

Introduction of the computer into the composition process occurred very slowly at first and then during the last several years has accelerated very rapidly. According to an annual survey made by "Composition Information Services," an industry newsletter, in 1964 only 77 companies throughout the world used computers in typesetting applications. In 1969 that number had grown to almost 1,100 companies. Growth in the total number of units installed was 54 percent from 1967 to 1968 and 33 percent from 1968 to 1969.

Computers used in typesetting applications are of both a special purpose and a general purpose nature. The special purpose computers once dominated the field because of their low price (often under $25,000) and ability to provide the limited services initially desired, such as hyphenless justification of text material. At the end of 1969 they constituted about 50 percent of the installed units, but their penetration is expected to drop rapidly.

General purpose computers, while often dedicated to typesetting functions, are also capable of performing business and accounting functions. The medium sized computers, IBM 360/30 or 360/40 and RCA Spectra 70/35 or 70/45, used with CRT phototypesetters, are capable of performing the complex work of full page make-up. It is use of the computer in complex applications such as this, where human labor is reduced, that will most read-

ily justify computerized typesetting.

Hot Metal Typesetters

Hot metal linecasters are still extensively used in the typesetting of printed material. These machines use a directly interfaced keyboard or punched paper tape to direct a small, brass, recessed character mold to drop from an overhead rack into a jig containing a line of type being set. Wedge shaped space bands are used between words to automatically justify each line. Line by line, hot metal is cast into the molds to form a line of raised type called a slug.

The sales of hot metal linecasters have declined slightly during the past five years. Unit sales in the domestic market, including Canada, are expected to decline significantly over the next five years but

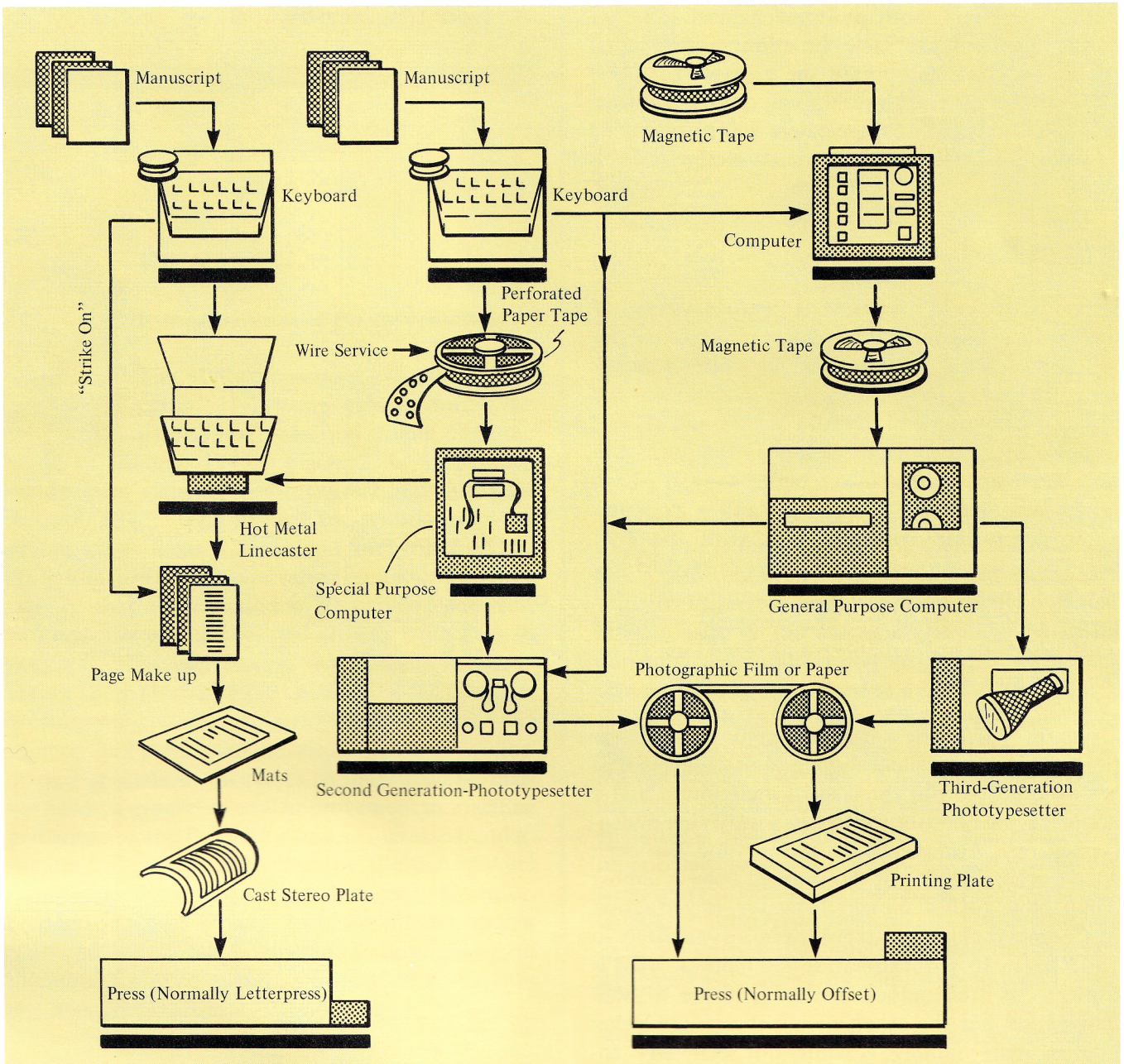

FIG. 1. The Typesetting Process

increasing penetration of foreign markets should keep the overall annual decline to less than 10 percent. Continued inflation during those five years should keep annual declines in revenues to approximately 5 percent. The majority of all typesetting is still done by hot metal linecasters, even in the United States. Significant use of hot metal typesetting is expected to continue past 1975.

Phototypesetters

Phototypesetters, both photomechanical and electronic, perform the same function as hot metal typesetters but incorporate the greater speed and flexibility of advanced mechanical, optical and electronic systems. Phototypesetters will be discussed in detail throughout the remaining sections of this report.

Strike-on Typesetting

Strike-on or "cold" typesetting involves the use of standard typewriter keyboards, supplemented by additional coding keys, to produce camera ready composed copy. The best known systems are the Friden Justowriter and the IBM MT/ST and MT/SC combination. In both cases a recording unit converts keyboard strokes into a coded tape, a 7-level paper tape with the Justowriter and a noncomputer compatible magnetic tape with the IBM MT/ST. Then a reproduction unit is used to justify and rapidly type the copy from the prepared tape. Other systems are also available including units which record, compose and reproduce all on the same unit.

Strike-on typesetting is used in graphic arts applications primarily by small shops and newspapers that are unable to afford the cost of a computer and a nonjustifying phototypesetter or a justifying phototypesetter. Acceptance of the method has been good because quality of the finished copy is almost comparable to hot metal. However, introduction of Compugraphic's inexpensive phototypesetters in 1968 began to seriously erode the market. IBM is utilizing its tremendous marketing force to hold its position but the other manufacturers are losing market share rapidly. While not officially announced, it appears that Friden has stopped serious marketing of the Justowriter.

Consumables

This component includes the phototypesetting paper and film, stabilization paper and offset plates required in phototypesetting applications. Consumption of supplies is expected to grow faster than the phototypesetting market because machine users will continue to operate and increase the utilization of existing machines even when additional equipment is no longer purchased. Consumables are one of the most profitable components within the typesetting industry.

2 THE MARKET

Estimated Sales of Phototypesetters

The phototypesetting industry has experienced dynamic growth during the past several years and should continue to do so through 1975. Figure 2 shows the estimated sales value of phototypesetting units sold through 1975. The market for phototypesetters should grow from $49 million in 1969 to $146 million in 1975. The equivalent compound growth rate for that entire period is 20 percent per year, although the actual expected growth from year to year will differ significantly from this, as shown in Figure 3. During 1970 a backlog of demand pressure for phototypesetters is building within the printing and publishing industry. The introduction of new specialized machines to meet specific market needs, a general overall improvement in machine performance and flexibility, and an increased understanding of photocomposition by the industry are responsible for this pent-up demand. However, postponement of buying decisions due to current economic conditions is expected to limit growth in the sales of phototypesetters from 1969 to 1970 to less than 20 percent.

If the economy improves in 1971 as predicted, pent-up demand for phototypesetters should be released, pushing 1971 annual sales 34 percent above those for 1970. From this point annual growth is expected to gradually decline with 1975 sales 13 percent above those of 1974.

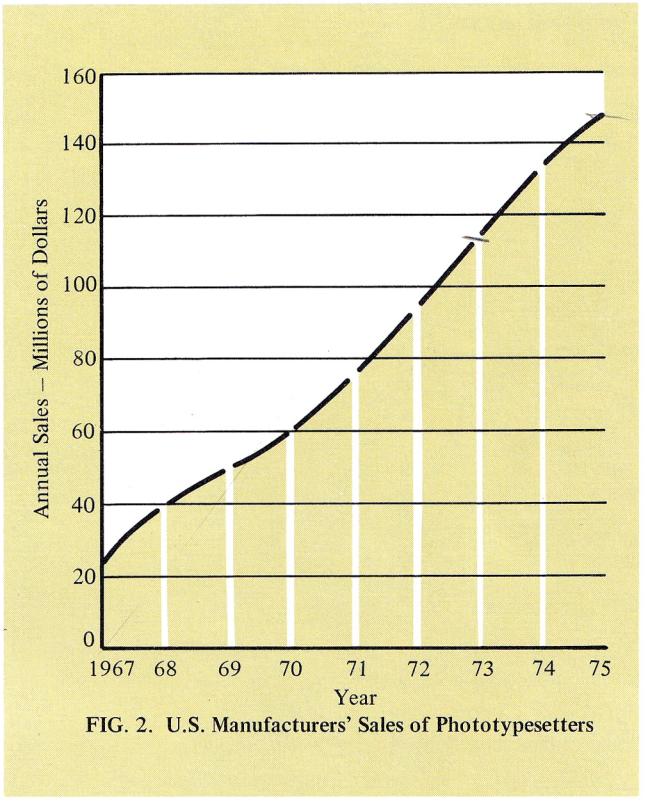

FIG. 2. U.S. Manufacturers' Sales of Phototypesetters

The estimated sales value of phototypesetters depicted in Figure 2 includes only the sales value of the typesetting units. It does not include the sales value of keyboard entry units, unless the unit is an integral part of the machine and included in the purchase price, nor other associated equipment unless normally purchased as part of the system. It does not include the value of supplies consumed by the phototypesetters or associated equipment during operation. The value of magnetic tape drives is included only in those cases where the tape dirve is an integral part of the equipment and included in its purchase price. It does not include the value of computers used with the phototypesetter in a computer typesetting system. It does include the value of control computers included in the design and purchase price of the phototypesetter.

Most photomechanical phototypesetters are sold by direct purchase while most cathode ray tube (CRT) units are leased. To determine the estimates given in Figure 2, all sales values were calculated as

though units sold were purchased rather than leased. This was done to provide a consistent measurement base and to avoid the confusion of numerous lease plans with varying impacts upon the sales account.

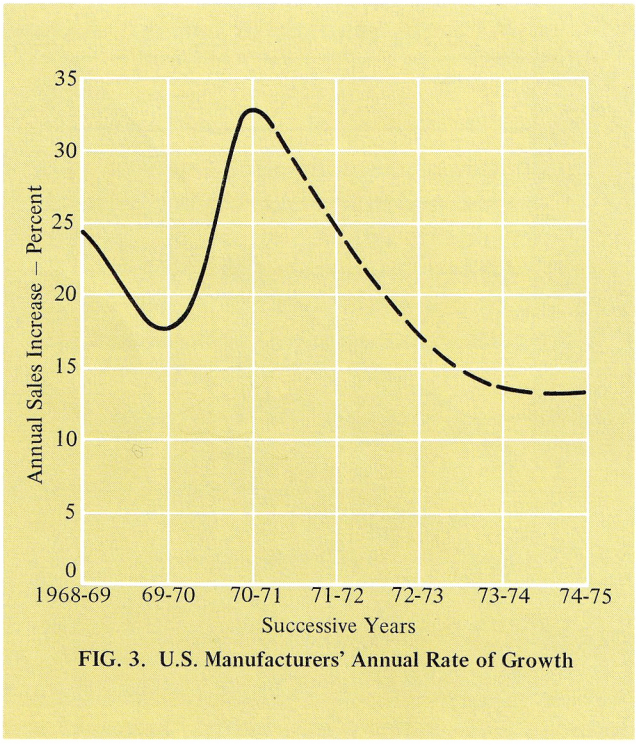

FIG. 3. U.S. Manufacturers' Annual Rate of Growth

Demand

The demand for phototypesetters arises from the following major factors:

- The increased use of computers for typesetting composition work.
- The increased use of computer data banks to initiate material for typesetting.
- The rapid growth of the offset printing process.

Phototypesetters are increasingly being used in computer typesetting systems because they provide the output speed and typographic flexibility required to optimize the system. A great variety of phototypesetting units provide an ever-increasing selection of machines to meet a specific need and cost. The large, expensive CRT units provide great speed and flexibility together with the potential to greatly enhance system efficiency by restructuring the process of editing and page make-up.

The ever-increasing number of data banks available through magnetic storage media is also increasing the demand for phototypesetting. Computer operators are finding that data prepared and stored for one use may have economic value when published in a condensed or varied format. By programming the computer to reformat and compose the data in the desired typographic form, the expensive and time-consuming process of keyboard entry can be avoided. Input of material into the system at computer speeds is a key to many expanded applications for phototypesetting.

Offset lithography is well suited to phototypesetting because lithographic plates can be made rapidly and economically from the output (film or paper positives) of phototypesetters. As lithography has grown to account for over 50 percent of the commercial printing shipments in the United States, phototypesetting has been more readily accepted. Continuing research and advances are being made toward economic utilization of phototypesetting film and paper for the production of letterpress printing plates, but the required breakthrough has yet to be achieved. Penetration of the letterpress process would significantly increase the potential market for phototypesetting because the bulk of printing not done by the lithography process is done on letterpress presses.

Computer Output Microfilm

Computer output microfilm (COM) systems, covered in the June 1970 report, **MICROFILM INDUSTRY-I**, constitute a new competitive threat to photocomposition. COM machines are extremely fast and are priced significantly below CRT phototypesetters, but they do not have the ability to store and typeset numerous fonts with the resolution required for many high-quality applications. Inclusion of these added features would both decrease the speed and increase the price of existing COM units.

It is anticipated that COM systems and CRT phototypesetting systems will primarily complement each other for the next several years, with COM systems and service bureaus making some but not significant inroads into traditional areas of photocomposition. As both CRT phototypesetters

and COM recorders evolve and gain market maturity over the next five years, it is expected that product and market differentiation between the two systems will decrease.

International

The international market for phototypesetters is a significant one. As early as 1966 a survey made by "Composition Information Services," an authoritative trade newsletter, found the international market to be 40 percent as large as the domestic. Industry sources indicate that this gap is rapidly being closed so that foreign markets may shortly be as large as the domestic one.

The older United States manufacturers—such as Photon, Mergenthaler and Harris-Intertype—have had established international marketing forces or arrangements for many years. Compugraphic has expended considerable energy during the past year in expanding and solidifying their international marketing organizations. RCA is restricted from selling the Videocomp outside the United States because the rights they purchased to manufacture and market the machine were for the United States alone. All sales made outside of this market are made by the machine's originator, Dr. Rudolph Hell of West Germany. Dr. Hell's unit is called the Digiset and is currently in 17 installations throughout the world.

Sales by Manufacturer

Figure 4 shows the estimated annual sales value of phototypesetters shipped by major manufacturers. The figure indicates that those manufacturers concentrating on primarily low-cost units should maintain continuous growth through 1975, although they will not attain market leadership because of extensive competition and a low revenue per unit sold. Manufacturers depending primarily on sales of the expensive CRT units should find their sales volume starting to diminish by 1973 or 1974 unless they take steps to move into new market areas.

In analyzing Figure 4, one consideration should be mentioned. The market for phototypesetters is currently quite volatile as new models and companies are being announced with a rapidity which confounds much of the industry. Models are normally announced long before they are ready for production and may even be superseded by a new model before production of the "old" model begins. Therefore, it would not be surprising to see several new companies take significant positions within the market. IBM, after an unsuccessful entry into the market for large, CRT phototypesetters, is rumored to be testing a smaller CRT unit to compete with the Mergenthaler Linotron 505. Xerox is also thought to be interested in the CRT phototypesetting market as is an English company, Crosfield Electronics, which may market through Photon.

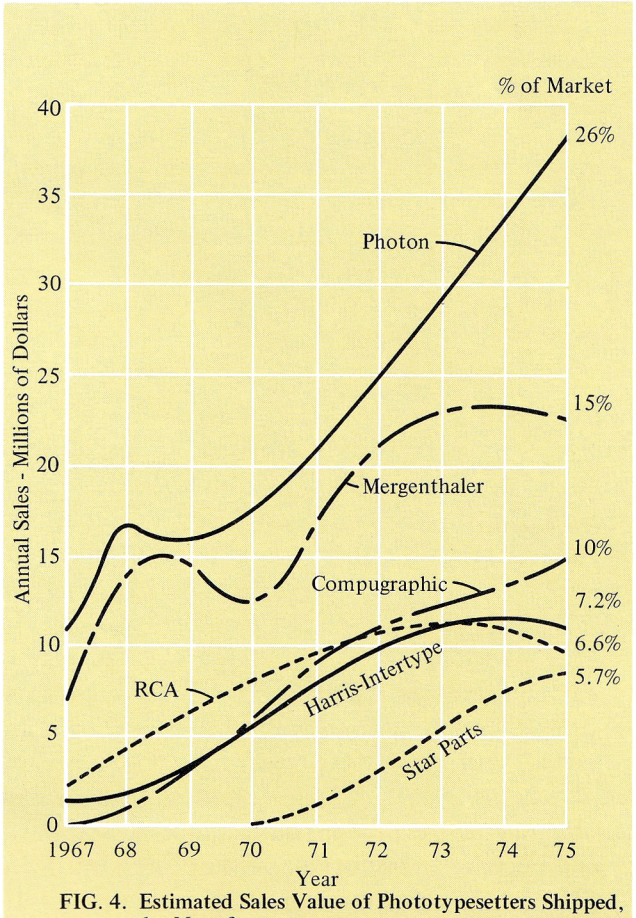

FIG. 4. Estimated Sales Value of Phototypesetters Shipped, by Manufacturer

Market leadership should continue to be shared by Photon and Mergenthaler until approximately 1973. At that point Photon is expected to increase its

lead as Mergenthaler encounters increasing competition for the Linotron 505. Photon's anticipated leadership should result from:(1) a strong marketing orientation, (2) a broad line of products directed toward high-growth markets, and (3) innovations such as the Model 7700, a computer peripheral phototypesetter. The market for the 7700 is in supplemental use with other computer output devices, such as line printers and alphanumeric COM units. Significant applications include: (1) computer reports of book quality and on 9-1/2 x 11 inch paper for company executives, (2) printing of contracts and insurance premiums, and (3) printing of catalogs for customer use. While Photon's forecast of 5000 units installed within five years seems somewhat optimistic, CSI predicts that sales of the 7700, in concert with the rest of their product line, will retain market leadership for the company.

Mergenthaler's sales should grow rapidly due to the Linotron 505. This unit is filling an unmet need in the market and should be the beneficiary of significant pent-up demand before several other manufacturers, yet to be determined, produce competing equipment. Both RCA and Harris should initially do well with their expensive CRT units, but will feel the effects of an oversaturated market by 1975.

Compugraphic currently is growing very rapidly because its products are filling a previously unsatisfied need in the market, the low-cost text-oriented phototypesetters. Friden is also producing two inexpensive units, but is not expected to compete effectively in the low-priced market. A company new to phototypesetting, although not new to the typesetting industry, Star Parts, has demonstrated an inexpensive unit which appears to have exciting potential. Delivery of the machine should start the latter part of 1970. If field installation work is as satisfactory as the demonstration model, Star Parts should become an important market force by 1975. VariTyper, a subsidiary of Addressograph-Multigraph, is currently marketing a $20,000 unit which is receiving good market acceptance. With the 500-man Addressograph-Multigraph marketing force behind its products and the addition of a smaller machine to the product line later this year, VariTyper should gain considerable market share. It should be noted that the VariTyper phototypesetter is produced by Photon for VariTyper. The effective result is sales penetration for Photon in a market segment where it has chosen not to enter equipment under its own name.

3 MARKET SEGMENTS

The market for phototypesetters can be divided into five segments, according to price range and capability, as follows:

Low-Priced, Text: less than $15,000
Low-Priced, Versatile: $15,000 - $30,000
Medium-Priced, Typographic: $30,000 - $75,000
Medium-Priced, Electronic: $75,000 - $200,000
High-Priced, Electronic: more than $200,000

The first three segments constitute all of the photomechanical typesetters sold except the Photon ZIP. The ZIP sold for $250,000 and could be considered in a fourth market segment, high-priced, typographic. However, since the machine has been made virtually obsolete by the electronic phototypesetters and since sales are expected to be negligible in the future, the ZIP and its market segment will no longer be considered. The last two segments contain the electronic phototypesetters based on cathode ray tube (CRT) technology.

The estimated growth in each of these segments is shown in Figure 5. The figure indicates the nature of the pent-up demand discussed earlier. The medium-priced typographic market segment which emphasizes typographic versatility and output quality is expected to lose much of its dominance to the new markets surrounding it. Until 1968, three of the market segments, low-priced text, low-priced versatile, and medium-priced electronic, did not exist in their current form. Several machines sold in the $15,000 to $30,000 price range before 1968 are still available but cannot compare in output speed and typographic versatility with the newer equipment recently announced.

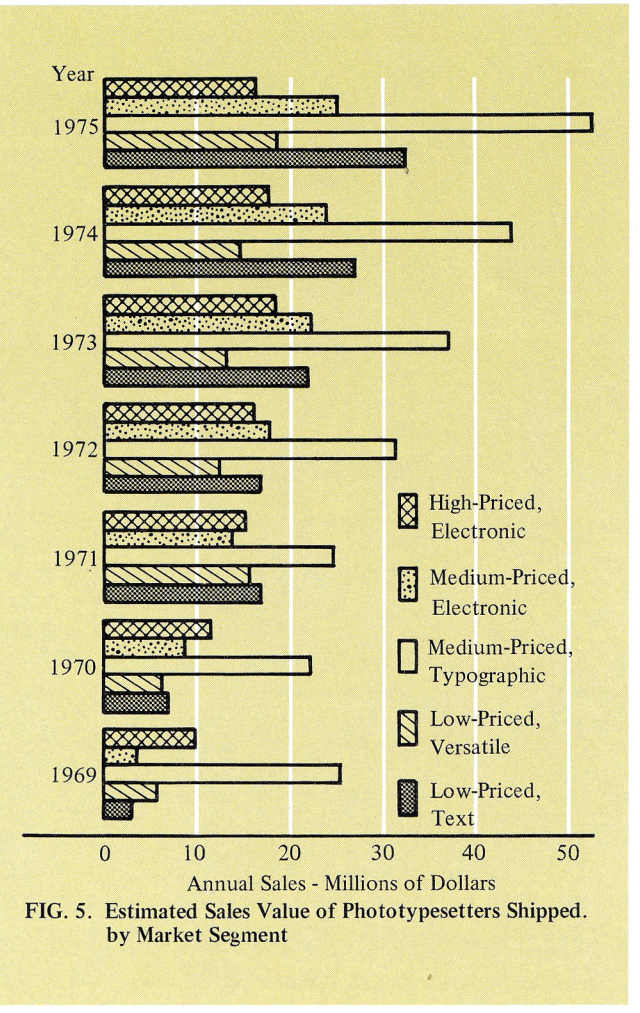

FIG. 5. Estimated Sales Value of Phototypesetters Shipped. by Market Segment

Even more demonstrative of the change in the industry is Figure 6 which shows the estimated sales of phototypesetting units for each market segment. Low-priced units that are typographically limited to typesetting of text material are anticipated to grow from zero units sold in 1967 to over 60 percent of the number of units sold in 1975. The proliferation of these inexpensive machines is expected to drop the average price of

phototypesetters sold from $46,000 in 1968 to $26,000 in 1975.

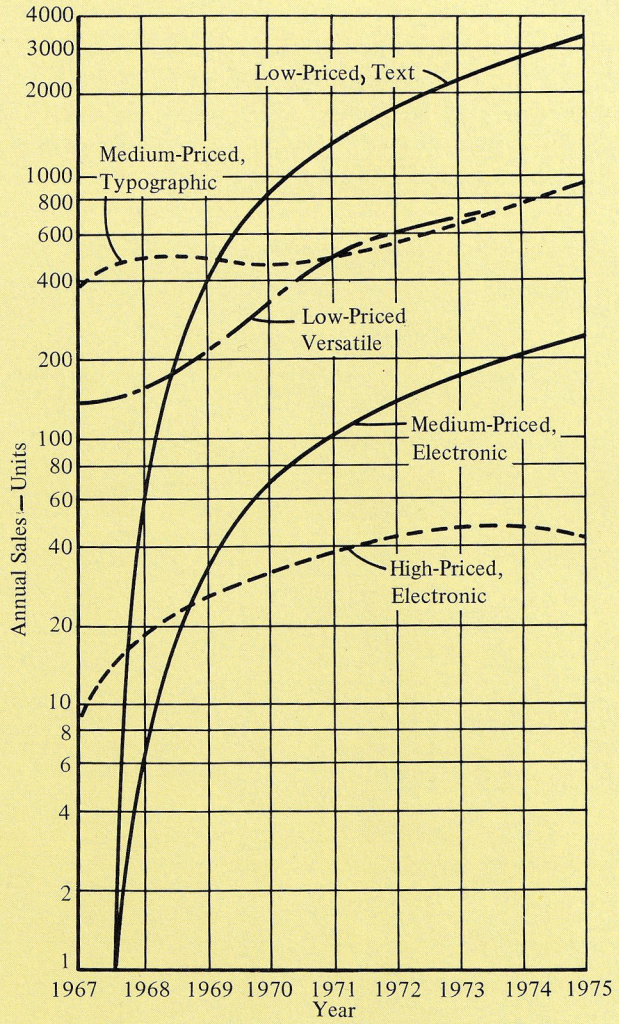

FIG. 6. Estimated Sales of Phototypesetting Units, by Market Segment

The characteristics of each market segment and its potential customers are described below.

Low-Priced, Text

In general, low-priced text phototypesetters offer fewer automatic features and typographic variety than found in higher priced units. The output speeds available are comparable with, and for the CompStar higher than, those generally found on other photomechanical units. This market segment is still experiencing rapid evolution and each new machine announcement includes broadened capabilities and improved performance.

Phototypesetters in this market segment are aimed primarily at applications that produce large amounts of textual material in specified formats. They provide photocomposition at an economical cost for applications where fully automatic tape-controlled operation and typographic diversity are not required. Typesetting of newspaper text and most book composition is the primary potential use for these machines.

Inexpensive phototypesetting machines are having the greatest competitive impact on "cold" type or strike-on typesetters such as the Friden Justowriter and may make obsolete much of the cold type industry as it relates to printing and publishing. Small newspapers, book publishers and corporate in-house printing facilities, who formerly could not justify the purchase of higher priced photocomposition systems and had turned to direct impression or hot metal devices, now can take advantage of phototypesetting through purchase of these low-priced units. The advantages of phototypesetting over cold type or direct impression are: (1) higher output quality, (2) higher output speed, (3) greater flexibility and (4) computer compatability.

Companies currently offering low-priced text phototypesetters are Compugraphic and Friden. Additional manufacturers having announced new entries into this segment are Star Parts and VariTyper. Both new machines are expected to enter the market toward the end of this year or the first part of 1971.

Low-Priced, Versatile

Low-priced versatile phototypesetters are hybrid units that possess typographic capabilities greater than the specialized units just discussed but generally less than found on the more expensive photomechanical machines. They provide automatic tape control of a greater number of typefaces than the straight text-oriented machines and often in several point sizes. Generally the point size range is great enough to perform some display as well as text work. Several older machines, the Alpha-

type and American Type Founder's ATF B-8, are priced within this market segment but are not competitive. Their future effect on the market should be quite small.

The primary markets for these machines are small- to medium-sized newspapers and publishers who require some, but not a great deal of, font mixing. The limited display capability is an added benefit that should enhance the desirability of the units for this market. Before introduction of these machines, many potential users of photocomposition who required greater typographic flexibility than offered by the inexpensive text units and who could not justify expenditure for the large, general purpose phototypesetters continued to use the hot metal process.

Current manufacturers of hybrid phototypesetters are Photon, Fairchild Graphic Equipment, and VariTyper. Additional manufacturers with announced products expected to begin delivery by the end of the year include Mergenthaler, Friden, Compugraphic, and Graphic Systems, a newly-formed company. The newness of this segment suggests that this list of manufacturers will not remain static. Additions and consolidations should be expected.

Medium-Priced, Typographic

Medium-priced typographic phototypesetters are general purpose machines which normally offer a large "on-line" font library with a broad range of point sizes available under automatic tape control. These units normally have the capability of automatically mixing fonts, and often point sizes, within the same line. They also can do display work since most can set type up to 36 points (1/2 inch high) and many up to 72 points. Photon's Model 7700, the computer peripheral phototypesetter discussed earlier, will be considered within this market segment.

The primary markets for these general purpose phototypesetters are large newspapers, publishers of complex catalogs and directories, and large printers who do a variety of work on a job-shop basis. Newspapers use them for both text and display work with the display being more important. They can provide speed and flexibility greater than that of display machines used solely for that purpose. Complex catalogs and directories often require a great deal of font mixing within a line and particularly within a page. Use of a machine capable of automatically mixing typefaces reduces the time spent in page makeup.

This market segment is the oldest, largest and least volatile. The manufacturers supplying it have been heavily committed to the typesetting industry for many years. New equipment introductions are for the most part extensions or revisions of an existing product and not brand new machines. The output speed of products sold in this market is gradually increasing, but primary emphasis remains on high-quality and typographic versatility.

Manufacturers currently supplying the market are Fairchild Graphic Equipment, Harris-Intertype, Mergenthaler and Photon. Photon has built its industry leadership in this market segment and continues to offer a broad selection of products by selected variation on several basic configurations. The other three manufacturers currently offer a limited product line of one or two machines.

Medium-Priced, Electronic

There is currently only one medium-priced electronic phototypesetter, the Mergenthaler Linotron 505. In the Linotron 505, electronic and mechanical systems have been joined to provide an inexpensive combination of electronic speed and flexibility. Although both the speed and flexibility are significantly less than those of the purely electronic machines, the price of these units makes them very attractive.

The Linotron 505 was initially developed in Europe by an English company, Purdy and McIntosh. (Mergenthaler now has manufacturing and marketing rights to the unit.) It was designed for the European market and has had good acceptance there. In the United States, the primary users of these machines are large newspapers. Typesetting service bureaus and large commercial printers are secondary markets.

It is anticipated that one and possibly several additional manufacturers will enter this market. Most immediate speculation rests on IBM as it reportedly has a working prototype being tested at a facility in Boulder, Colorado. Photon has also been mentioned as a likely candidate to market a unit being developed in England by Crosfield Electronics; however, since development work has yet to be completed, no definite plans have been made. In any case, look for at least one competing product to enter this market segment in the next several years.

High-Priced, Electronic

High-priced electronic phototypesetters are fully electronic machines based on cathode ray tube technology. The only exception to this is the Mergenthaler Linotron 1010 which uses a photographic technique for storage of master character sets rather than digital storage. These devices are designed to couple high output speeds with virtually unlimited typographic flexibility.

All machines must operate as part of a computer system as they require computer-prepared magnetic tape input to control their activity. As a result, machine efficiency is largely controlled by the composition programs driving the main computer. Until recently, only RCA has had sufficient programming support to penetrate the market in volume. All manufacturers, assisted by many programming and computerized typesetting service bureaus, are now beginning to de-emphasize hardware capabilities and emphasize the total system.

The primary market for these expensive units is the large printer and the service bureau that has one or two major customers which produce sufficient volume by themselves to justify the machine. It is the opinion of most industry sources that a majority of CRT phototypesetting installations are currently unprofitable because equipment was purchased before commitments were obtained by a major customer. RCA has estimated that a printer should anticipate at least $2 million annual gross receipts before he considers a CRT unit. Other estimates have put the break-even volume as low as $60,000 per month. In any case, the income required to support a large CRT phototypesetting system is substantial in view of the small job-shop nature of the printing and publishing industry.

In an extensive economic study of CRT phototypesetting systems conducted for the United States Department of Health, Education and Welfare by Mr. Edwin R. Lannon, several conclusions of particular interest came forth:

- The level of production required to justify installation of a CRT phototypesetter over a conventional photomechanical unit for one-time typesetting applications is higher than normally expected by most printing firms. While not dealt with specifically in Mr. Lannon's report, industry experience has shown that break-even production volumes can be significantly reduced when a CRT unit is used for applications not requiring input from directory entry keyboards. An example would be the typesetting of material contained in existing data banks.

- Computer costs are the controlling factor in a computerized CRT phototypesetting system. Speed of the computer is inversely related to the relative cost of the system—i.e., the faster the output capability of the host computer, the more economical the system becomes. Since IBM has announced the System 370, a series of computers with increased performance-to-price ratios, the relative attractiveness of CRT phototypesetters should increase.

- To take full advantage of the great capacities of CRT devices, specialized computer systems may be required that utilize high-speed hardwired circuitry for often repeated functions in place of extensive software control programs. Mergenthaler has developed such a system, called the Format Processor, for the United States Air Force. IBM has also spoken of the "firmware" concept where a computer's hardware capabilities can be altered by programming techniques. The result is a step toward a specialized computer for each individual user that can produce significant increases in output speed. There is speculation that IBM may introduce this feature on its forthcoming fourth-generation equipment.

A major market CRT phototypesetter manufacturers are trying to penetrate is the newspaper market. To date little success has been achieved because most large daily newspapers still use the letterpress process and because last moment changes in page makeup that are inherent in newspaper publishing require individual column galleys for maximum flexibility. CRT phototypesetters are designed for economic operation when producing full pages rather than individual galleys. It is anticipated that major breakthroughs into the newspaper industry are many years off if they occur at all. Some penetration into the very large newspapers may occur for the setting of classified ads (RCA has delivered a Videocomp to the L.A. Times for such a purpose), but this is expected to be a limited market.

Only three United States manufacturers now produce CRT phototypesetters, Harris-Intertype, Mergenthaler and RCA. IBM did sell a few CRT devices designed, developed and produced by Alphanumeric, but has withdrawn from the market. It is not anticipated that any additional manufacturers will enter this market.

4 TECHNOLOGY

Phototypesetting is now considered to be in its third generation of equipment development. First generation devices borrowed many operating principles from hot metal linecasting machines but used photography in place of actual metal casting. Individual glass characters were used to reflect light onto a sensitized surface to obtain the desired image. These devices will not be discussed as they are no longer produced and sold.

Second generation devices use photomechanical methods to select and expose character images on photographic film or paper. These machines were originally developed in the 1950's and have undergone continual refinement ever since. Third generation devices are fully electronic machines based on cathode ray tube (CRT) technology. They were developed around 1965 and are still undergoing significant changes. Both second and third generation phototypesetters will be discussed in this section.

Second Generation Phototypesetters

Second generation phototypesetters produce typeset copy from master character sets stored photographically within the machine. The major subsystems used to produce the copy include input, character selection, image output control, and interline separation. Although the basic principles used by all manufacturers are similar, numerous variations in design complexity and configuration present a vast array of alternative methods for setting the copy. Figure 7 illustrates the basic components found in most systems. To give a manageable picture of second generation phototypesetting technology, discussion will be limited to a general review of basic operating principles together with detailed descriptions of the most popular and most significant systems.

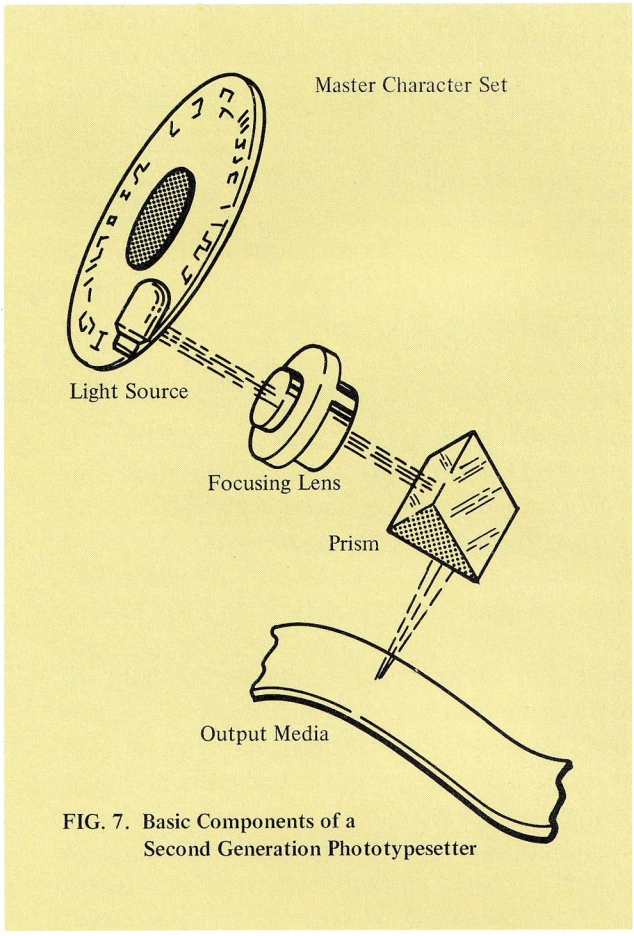

FIG. 7. Basic Components of a Second Generation Phototypesetter

Input Systems

Phototypesetters use codes from an input source to initiate a series of machine responses that produce typeset copy. The codes identify parameters that control the operation including:(1) characters to be typeset, (2) desired fonts and point sizes, (3) inter-

word spacing for line justification, and (4) desired interline spacing.

Input sources for second generation devices are: (1) direct keyboard entry, (2) keyboard-controlled perforated paper tape, and (3) computer-controlled paper or magnetic tape. Most early sytems used data entry by keyboards directly interfaced with the machine and designed for use by skilled operators who understood the function codes required to typeset copy and who could divide the copy into justified lines. This method was slow because of end-of-line justification decisions and extra coding strokes had to be made manually.

As newer, faster, and more flexible phototypesetters became available, the use of keyboard controlled perforating units for paper tape became more popular. These units changed keyboard text entry into an off-line operation and made the use of multiple keyboards for a single phototypesetter possible. This method also allowed the typesetter to operate at its maximum speed rather than that of the keyboard operator. At present, many keyboard perforators are further offering built-in controllers with memory cores that automatically produce function codes and justify lines of copy. Two benefits result from this capability:

- The broad skill levels required of keyboard operators are lowered, thus reducing labor costs.

- Input emphasis is on speed and accuracy rather than function codes and justification.

Electronic digital computers are also used to prepare input tapes for phototypesetters. Hardwired, special purpose computers have been specifically designed for this task. These computers normally prepare perforated paper tape that contains all the function and control codes required to operate the typesetters, together with the text in a justified format. Most special purpose computers use interword spacing to justify a line and are incapable of using end-of-line hyphenation except through human intervention.

Perforated paper input tapes for second generation phototypesetters may also be generated by general purpose digital computers. These computers normally provide the flexibility and speed to perform composition work on a variety of large, complex typesetting jobs as well as other business applications. General purpose computers enjoy an advantage over special purpose machines in that they are capable of taking information from computer-generated data banks, e.g., telephone directories or parts catalogs, and, under the guidance of an appropriate program, prepare it for phototypesetting without the step of keyboard entry. Elimination of this step greatly enhances the efficiency and accuracy of the total system, as keyboard entry has historically been a bottleneck in the photocomposition process and is the point of introduction of many errors into the copy.

An additional input source available with some phototypesetters is computer-generated magnetic tape. Magnetic tape carries the same coded input data as paper tape and permits much higher entry speeds with improved handling characteristics.

Character Selection

The character selection subsystem consists of light source, master character set, and control logic to synchronize the light source and character set. The light source is of high intensity and may be a continuous source or may operate stroboscopically with a flash duration of one or two microseconds (millionths of a second). The light source normally used is a xenon flash lamp or flash tube. For larger point sizes the lamp is flashed twice to assure that the film is fully exposed for uniform character blackness. One phototypesetter uses a spark gap light source that automatically increases spark intensity as the point size increases to maintain uniform blackness.

Master character sets are transparent negatives (clear characters on opaque backgrounds) which supply character images in the typeface or font desired. As illustrated in Figure 8, master character sets are stored on: (1) rotating discs, (2) rotating drums with interchangeable film strips, (3) rotating turrets, or (4) stationary grids. In all cases, master character sets are interchangeable to permit insertion of desired fonts not already in the machine. Some phototypesetters offer multiple character arrays

with up to five discs or four grids in a pinwheel arrangement.

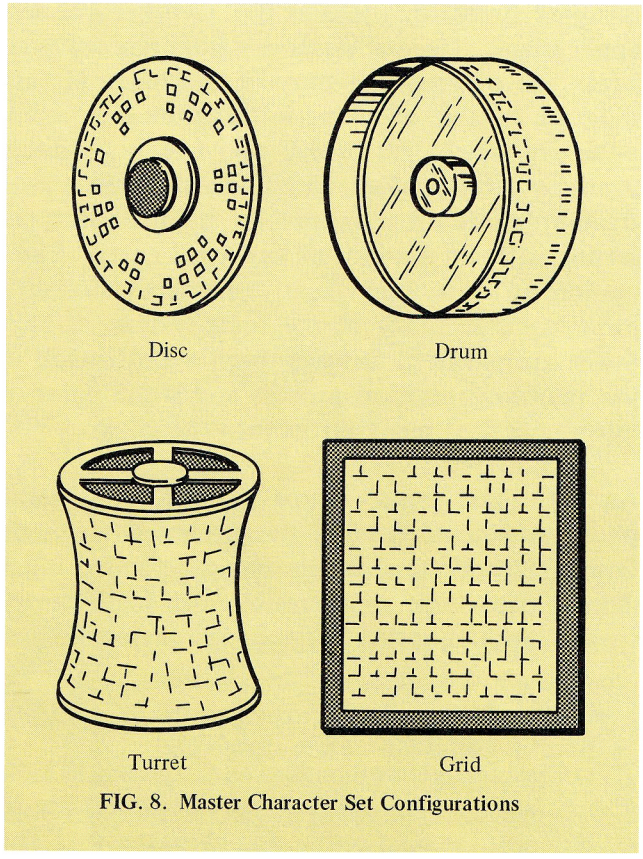

FIG. 8. Master Character Set Configurations

The process of character selection begins by coded information from the input source being read into the machine's control logic. As the logic unit recognizes the character and font code, it determines where the desired font is located in relation to the light source. In machines with single character set arrays, all available fonts are located in front of the light source. Multiple character set arrays may find the desired font at the opposite side of the pinwheel and require rotation of the proper disc or grid into position before the light source. Simultaneously, the logic unit is selecting the proper light source, when more than one is available, and positioning the apertures, mirrors, and lenses used to isolate the desired character. Isolation techniques will be discussed in more detail under the paragraph on image ouput control.

As the proper character image approaches the light source, most systems use a series of timing lines on the rotating master character set or timing pulses to synchronize action between the light source and the character image. On some machines the timing mechanism will cause the character to be projected to stop in front of the light source. However, on most machines the extremely fast stroboscopic light source is sufficient to obtain high quality output by simply flashing at the exact moment the character image is in front of the light source. Once the proper character is selected and its image is optically initiated, the second subsystem, image output control, begins action.

Image Output Control

The function of the image output control subsystem is to properly form and position the character image on the output media. Components of the subsystem include an optical projection mechanism to focus, direct, and magnify the projected light rays and a spacing mechanism to accurately provide intercharacter and interword spacing.

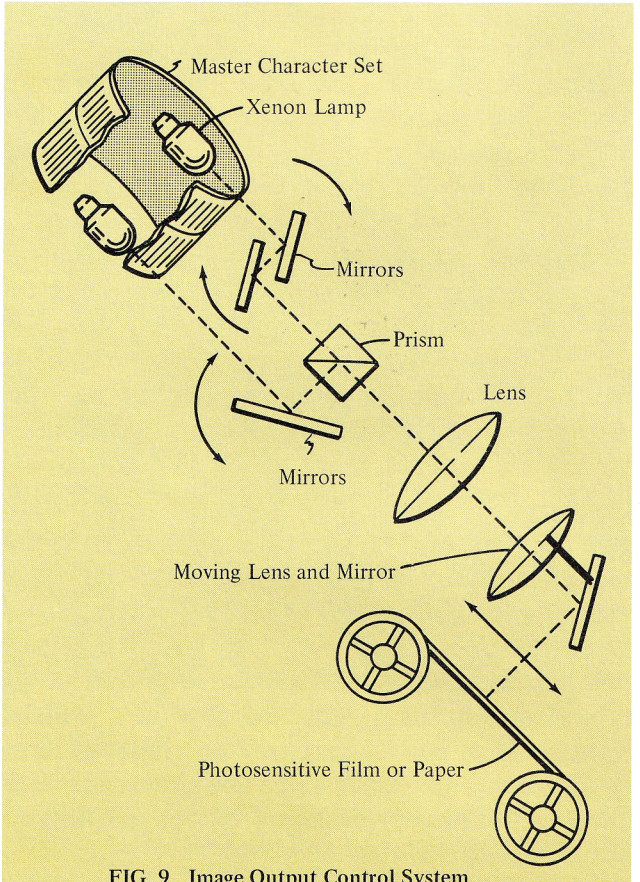

FIG. 9. Image Output Control System for a Rotating Master Character Set

The design of optical projection mechanisms varies significantly among phototypesetters. Their design and complexity are primarily a function of the master character set and the method of producing point size changes. Rotating character sets normally carry several fonts around the rotating surface. The stroboscopic light flash illuminates a complete row of characters rather than isolating individual characters. A series of apertures, mirrors, or lenses moves into a unique set of positions in response to function codes on the input tape. The desired character image is thus guided into the optical path while all others are deflected away. Figure 9 illustrates how such a system works. As the number of fonts on an individual rotating character set increases so does the complexity of the optical system required to isolate and project individual characters.

Stationary grid systems, as shown in Figure 10, are the most complicated systems of all for optical character isolation. Since character images on the grids are stationary and not rotating past the light source, a continuous light source is used. Light is distributed evenly over the grid by condenser lenses specifically designed for this purpose. The effect is illumination of an entire matrix of character images rather than a single row. The light rays from each character are formed into a beam of virtually parallel rays by a series of lenses called a collimator assembly. The rays then enter a series of eight pairs of optical wedges designed to isolate the desired character image. Directed by codes on the input tape, the wedges move to a unique set of positions, for that character. The refractive angles on the wedges guide light rays from the appropriate character along the optical path and deflect all others away. A decollimator assembly is used to converge the parallel light rays and restructure the character on the output media.

In typesetting, point size is a measure of font or type height. It measures the maximum height a font requires when adding together the maximum distance reached by characters extending both above and below the base line. A 72-point font requires one full inch to accommodate all characters within it. Normal text type ranges from 5 to 12 points and most newspaper and book headings are less than 18 points. Characters in point sizes over 18 points are normally considered as display characters.

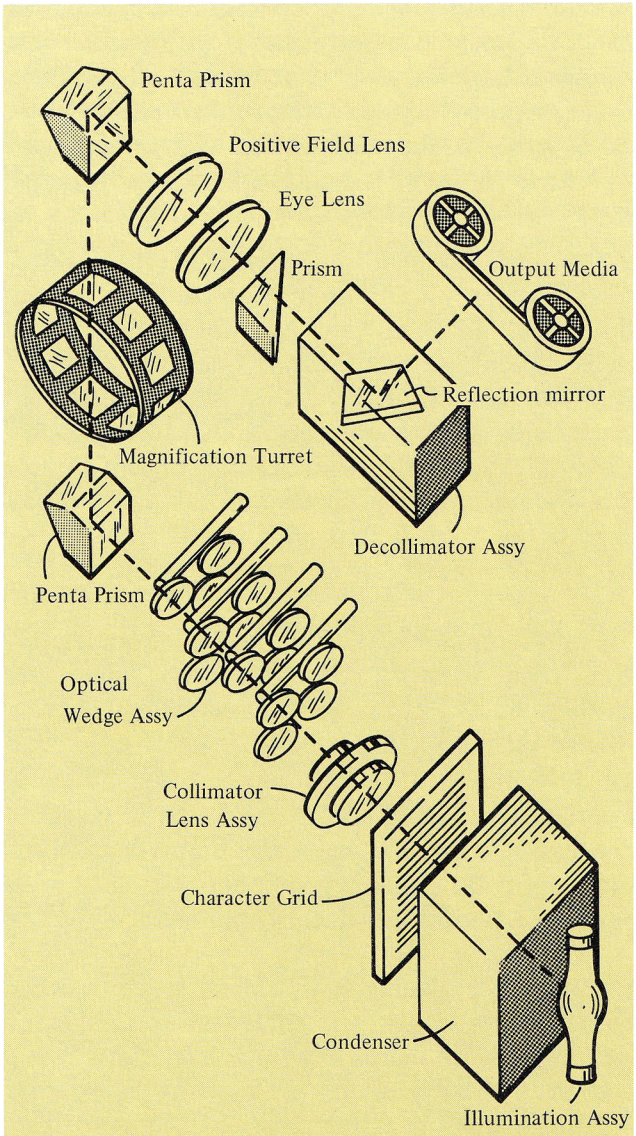

FIG. 10. Image Output Control System for a Stationary Master Character Grid

All phototypesetters have available a range of character point sizes, called the point size range, but differ significantly in the number of specific settings available and the method for changing point size. Systems vary from manual insertion to highly automatic selection of numerous settings.

Systems that require manual changing of point size permit by far the most straightforward and inexpensive design of the image output control subsys-

tem. In most of the low-priced text-oriented machines no mechanism to control point size is required, as manual changing of the master character set and the set-width gears is required. In several machines, manual adjustment of point size is accomplished by the setting of levers to correspond to the desired point size. Movement of the levers causes lenses in the main optical system to change position and vary magnification of the output.

In the more sophisticated Harris-Intertype Fotronic system, variations in magnification are accomplished automatically by movement of two lenses. Directed by function codes on the input tape, the movable lenses are driven along the optical axis by motors until positioned in the appropriate locations for the desired magnification. This system is very accurate and permits a broad range of point sizes, but adds significantly to the cost and complexity of the phototypesetter.

The most commonly used method of obtaining different point sizes is a multi-lens turret. The turret normally holds eight or more lenses which provide a range of magnification levels. Each magnification level relates to a specific point size. The appropriate lens is rotated into position in response to a coded command from the input tape. Lens turrets provide good typographic flexibility with reasonable photomechanical simplicity.

Intercharacter spacing is the blank space between the characters of a word. Interword spacing is the distance between words of a line. Variations in one or both of these measures are used to justify lines of type. Increasing or decreasing of interword spacing is the most generally used method for line justification. Intercharacter spacing variations are a secondary method normally used only in narrow measure, such as newspaper columns, when interword spacing exceeds a specified maximum limit. The size of the smallest incremental variation a machine can make is an important criterion in quality work.

There are numerous methods by which proper intercharacter or interword spacing can be achieved. Two basic components are involved, the mechanism that physically sets and advances character images across the output media and the logic system which controls the amount of advance and synchronizes it with the stroboscopic light source.

A lens carriage which moves laterally across the output media to locate the character properly along the typeset line is the most inexpensive method available. After each character is set, the lens carriage advances a distance equal to the appropriate character width and is ready for the next character image. Master character widths are either permanently hardwired into the circuitry of the phototypesetter or are available through changeable width circuits called width plugs. The character widths are then applied to the carriage advance through a pair of set gears that must be changed for each change in point size.

Another simple method for placing characters along the line is a positioning mirror that rotates to deflect the image the desired amount. Character focus is maintained by a focusing lens that moves in synchronization with the mirror. Rotation of the positioning mirror is controlled by a second optical system that generates electrical pulses to indicate the amount of rotation occurring. Rotation will stop when image deflection equals the appropriate character width. Perforated program tapes are used to load character widths into the machine memory in coded form. A new character width tape must be read into memory for each change in point size.

A third technique for correctly positioning characters along the line of copy involves a carriage that advances the light source and master character set laterally in relation to the output media. The carriage advance is determined by the character width contained in the device's memory. Loading of the memory from special coded tapes before typesetting begins is again used.

Movement of the output media carriage relative to the optical axis represents a fourth method for proper character placement. Between character flashes the carriage moves a distance equal to the character width but remains stationary while the light source is being flashed. Character width information is carried on the spinning discs that contain the master character set. Photocells located outside the optical system read the character width information on the discs to control movement of

the output media carriage.

The final method for proper character placement is a complex version of the original traveling lens carriage. In this system, illustrated in Figure 11, a carriage containing a lens and fixed mirror travels laterally in relation to the output media. However, the carriage is advanced only after several characters have been set on the film or paper. The task of proper character placement while the carriage remains stationary falls jointly to the character selection subsystem and the mechanism which isolates the desired character image along the optical path.

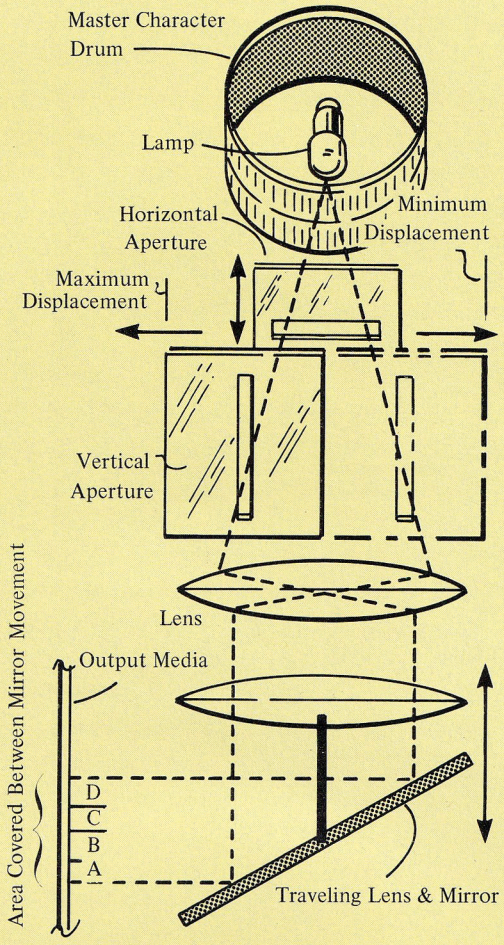

FIG. 11. Complex Configuration for Proper Placement of Characters

Immediately adjacent to the master character set are two movable apertures, one with two horizontal slits and one with a single vertical slit. Light passes through these apertures only at the intersection of the slits. Directed by the machine's control logic, the apertures are positioned so that light rays from only the desired character image pass through the intersection. However, due to control circuitry built into the machine, the projection of a specific character's image need not originate in precisely the same location each time the character is used. Timing of the light source flash and movement of the apertures can be controlled to vary the optical path between the displacement limits shown in Figure 11. Character width, interword spacing, and intercharacter spacing are all considered during movement of the optical path. Only after maximum displacement of the optical path has occurred will the carriage advance.

Interline Separation

Interline separation or leading is simply the distance separating sequential lines of typeset copy. After each line is set, the end-of-line function code from the input source triggers a mechanism that advances the film or paper the proper distance. Leading information is often entered through a manual setting on inexpensive phototypesetters but is generally entered as a function code on larger, more versatile machines.

Third Generation Phototypesetters

Third generation CRT phototypesetters produce typeset copy by means of electronic selection and exposure of character images on the face of a CRT. The major subsystems comprising a CRT phototypesetter include data input, character storage, character generation, and output pagination. Figure 12 is a diagram illustrating a general CRT phototypesetting system. The major subsystems will be discussed below.

Data Input

All CRT phototypesetters currently sold operate in an off-line mode. Three of the four machines use computer-generated magnetic tape as their only input source. The tape must contain the same character, function, and interline spacing codes associated with second generation devices. Magnetic tape is also used for font loading with those CRT photo-

typesetters using digital character storage. In the case of an RCA Videocomp without optional disc storage, the process of font loading may occur numerous times during a single job.

The fourth machine, the Mergenthaler Linotron 505, has an optional capability for magnetic tape input, but is primarily designed to operate from perforated paper tape input. In many ways, the Linotron 505 is more closely related to second generation phototypesetters than to other CRT devices; however, it will be discussed as a third generation device.

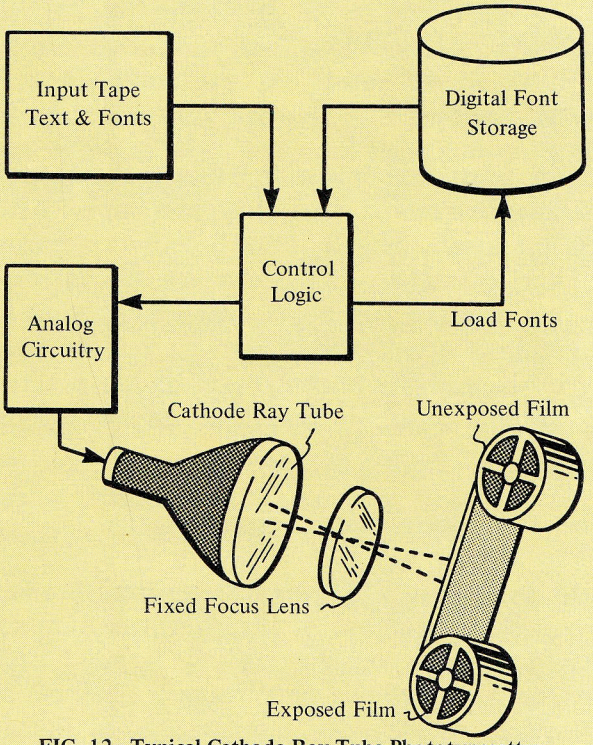

FIG. 12. Typical Cathode Ray Tube Phototypesetter

Character Storage

Character storage in third generation phototypesetters is accomplished by either photographic or digital means. Photographic storage requires the positioning of master character sets in the optical path. Master character sets contain clear character images on opaque glass grids. Eight fonts are stored within the machine on four individual grids. Access to fonts not already stored within the machine requires manual changing of the grids. During machine operation, the two fonts on the grid directly in the optical path are immediately available. Access to the remaining three grids or six fonts requires rotation of the grids into the optical path. The time delay associated with this movement ranges from 0.5 to 1.75 seconds.

Digital storage uses definition of character shapes by digital coding that is read and processed by a computer. The information required to describe characters digitally is so large that peripheral magnetic disc systems are required to maintain a reasonable font selection within control of the computer typesetting system. Magnetic disc systems are currently used in two ways, (1) directly interfaced with the main computer system or (2) directly interfaced with the phototypesetter.

Magnetic disc systems peripheral to the computer enter digital font information into the phototypesetter by magnetic input tape. Upon entry, the information is stored in the magnetic core of a small control computer. Here the information is available on-line as required; however, the memory is small, 32 thousand bytes with another 32 thousand available as an option, in relation to the requirements for digital character storage. As a result the number of fonts available within the machine at any one time is significantly restricted. Complex jobs will normally require frequent entry of new fonts into the core memory throughout the job.

The initial font information loaded into the phototypesetter for a particular task is read from the computer disc pack and written on the front of the input tape. Fonts to be entered during the course of a job are automatically interspersed with the text material on the input tape. Initial font loading and subsequent changes require approximately one second per loading.

Magnetic disc systems peripheral to the phototypesetter provide direct, on-line access to a large number of fonts. Digital font information is also initially entered into the phototypesetter by magnetic tape, but is written onto magnetic discs rather than stored in core memory. Up to 4,096 characters, or roughly 40 fonts, can be available for on-line access at any point in time. Changing of fonts during operation of a job is rarely needed due to the

large storage capacity of this system, but takes about 20 seconds when required.

Character Generation

Generation of character images for CRT phototypesetters occurs from electronic projection of character descriptions stored within the machine. Phototypesetters that use photographic storage employ two CRT's to generate character images. One CRT is a scanning device that describes the character and the second displays the character for exposure of the output media. Machines that store characters digitally use a single display CRT.

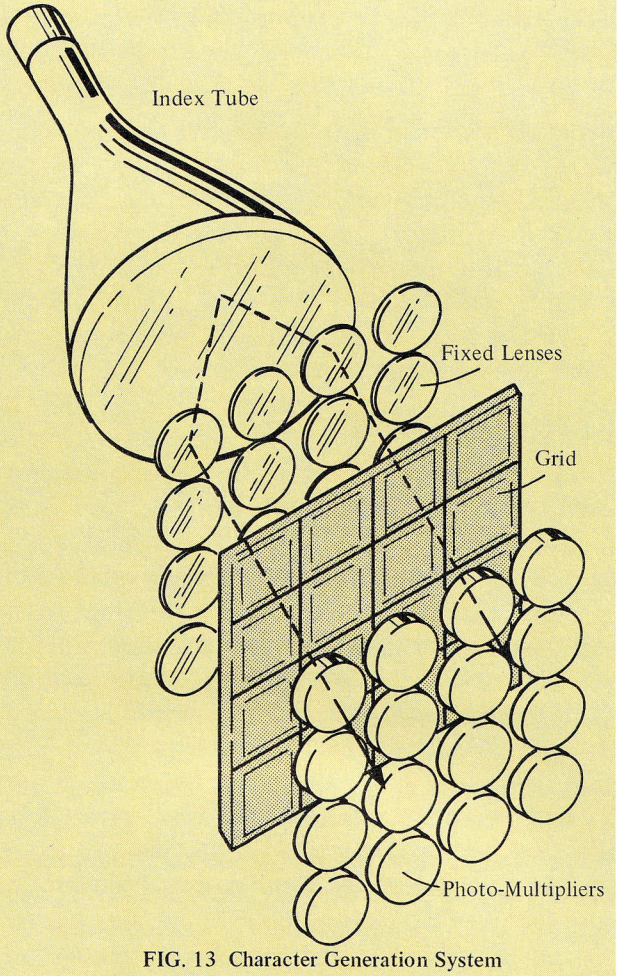

FIG. 13 Character Generation System for Mergenthaler Linotron 505

Figure 13 illustrates the character generation system used in Mergenthaler's Linotron 505. The 505 uses four glass grids to photographically store character images within the machine. When the appropriate grid is in place, the machine's control logic directs the scanning CRT to the desired character. The CRT's electron beam scans the character in a predetermined series of vertical scan lines. Scanning occurs at either 650 or 1,300 lines per inch, depending on the resolution required. A clear character image against an opaque background allows the beam to pass through the grid in the form of the character. The light passing through the grid strikes a photomultiplier which acts as an on-off switch. When light strikes the photomultiplier the switch is on and when no light strikes it, the switch is off. The electrical signals that result from this process describe the character being generated and are converted to analog signals that drive the display CRT in a series of synchronous strokes.

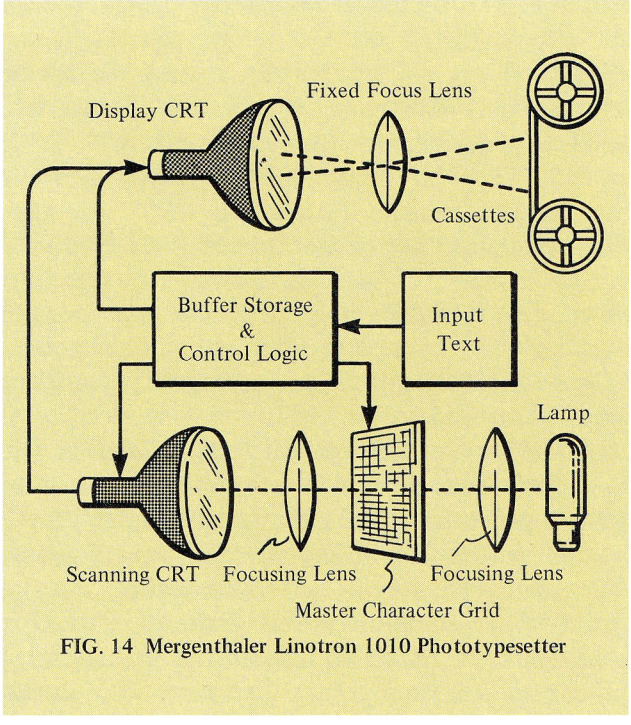

FIG. 14 Mergenthaler Linotron 1010 Phototypesetter

Figure 14 illustrates the Mergenthaler Linotron 1010 system which is similar to that just described except for the scanning method. In this system, a continuous light source projects light through the grid to the scanning CRT. The bombardment of light on the face of the CRT excites the tube's photocathode so that it emits electrons in the shape of the characters on the grid. The result is 256

electron clouds that correspond in shape to the grid's master character set. In the tube is an aperture system with 256 minute openings backed by an electrically-charged wire grid, also with 256 openings. As the cloud approaches the aperture, the machine's control logic electrically blocks all of the wire grid openings except the one corresponding to the desired character. A switch is turned on when the machine senses the leading edge of the electron cloud replica of the character image and is turned off when it senses the trailing edge. The electrical signals that result are converted to analog signals that drive the display CRT.

CRT phototypesetters that use digital character storage convert the digital description of the desired character to analog signals that drive the display CRT. In the RCA Videocomp, characters are stored and digitally described as a series of vertical strokes. This is done by dividing each stroke into a series of numbered segments and recording by digital code the number of the segment at which the beam is to be turned on or off during that stroke. The result is a series of electrical signals that describe the desired character.

The Harris-Intertype Fototronic CRT also uses digital character storage but describes the character through a matrix of individual dots. This system is designed to eliminate time spent sweeping over the blank or white space associated with all characters. Each character is divided into sections or matrices which are stored separately in memory along with the coordinates of the starting point for that section. The electron beam begins to write dots at the starting point for one of the sections. Additional dots are written according to sequential displacement instructions until an entire section is completed. Then the beam moves to the starting point of the next section and repeats the process until the character is completed. This method of digital storage requires approximately twice as much coding to store a character as that used with a scanning technique.

Also part of character generation for CRT phototypesetters is the system used to change point sizes. In scanning systems, height adjustments are made by changing the length of the stroke. Width changes are more complex and must be accomplished by either,(1) increasing the dimensions of the electron beam while spacing the strokes further apart, or (2) maintaining a constant electron beam size and using more strokes to describe the character.

CRT phototypesetters designed for photographic character storage vary point size by using a constant stroke width in the display CRT and increasing or decreasing the number of strokes used to describe the character. This is done by varying spacing of the vertical scan lines in the scanning CRT in relation to the point size. For example, for a 5 point width, the master character image would be scanned in half as many strokes as used for a 10 point width. When combined with a constant beam width in the display CRT, the result is a character width or point size in proportion to the number of scanning strokes.

Machines that use digital character storage change point size by varying the width of the electron beam. The digital coding that describes a character is for a single or master point size and must be electronically altered for all other point sizes. For example, generation of an 8 point character from a 5 point master would require a 60 percent electronic enlargement in the width of the electron beam, the distance between strokes, and the vertical measures. However, since resolution decreases in direct proportion to electronic enlargement, there is a practical limit to how many variations are possible from a single master point size. Both RCA and Harris-Intertype offer a series of point size ranges, each with a different master point size, that are designed to maintain high-quality resolution while giving as much point size flexibility as possible.

Output Pagination

Output pagination refers to the method used to generate a full page of typeset copy. The primary methods used are:(1) stroke, (2) line, and (3) page.

The stroke method is used by the Linotron 505. It is the most inexpensive design available but also restricts output speed. In operation, each stroke displayed on the face of the CRT is located in exactly the same position. No horizontal move-

ment of the electron beam occurs at any time. A mechanically driven prism lays down each vertical slice of the character one at a time. A series of timing lines synchronizes movement of the prism with generation of each stroke.

The line method utilizes horizontal deflection of the electron beam to typeset a complete line and a mechanical system to advance the film or paper between lines. This method is much faster than the stroke method because electronic beam deflection is faster than mechanical action. However, the extra speed is achieved at the cost of a more expensive, larger CRT and more complicated circuitry to compensate for distortion of the electron beam as it moves away from the center of the tube.

The page method uses both horizontal and vertical deflection of the electron beam to set a complete area or page of type without any mechanical movement. The output film or paper is advanced only between pages. While the fastest typesetting method of all, it is also the most expensive.

The Harris-Intertype Fototronic CRT uses a combination of the line and page methods. That is, it combines beam motion with motion of the output film or paper for both horizontal and vertical placement of characters. Horizontal character placement is accomplished by beam deflection across the full 11.5-inch width of the CRT display tube. In addition, the output film or paper is on a carriage that can be shifted sideways if a wider line is required.

Vertical character placement on the Fototronic CRT is controlled by logic circuitry which compares the desired output position with the actual position. For differences less than 1.6 points, the electron beam is deflected up or down to provide the necessary leading. When the difference is more than 1.6 points, the output film or paper is moved vertically until the output position is within 1.6 points of the desired position, at which point mechanical movement stops and beam deflection completes the move.

Future Trends

There are several developments in technology and applications that will significantly affect the phototypesetting industry, although it is too early to predict the nature or extent of their impact. These are described below.

The input of data to computer typesetting systems will become more automated. Optical character recognition readers will find increasing acceptance and application over the next three to five years. In the late 1970's, voice recognition techniques may also start to gain market acceptance. Creation of many microfilm information storage and retrieval systems during the next five years is expected to foster a demand for computer-input-microfilm recorders to provide a direct interface to micro-imaged data.

Electronic methods for proofreading and corrections will begin to find use in the editing process. Interactive CRT terminals will provide on-line display and correction of composed copy that is ready for typesetting. Harris-Intertype has just announced the first editing terminal available, called the Harris 1100. IBM is rumored to have a competitive machine fully developed, but no official announcement has been made by the company.

Processes that by-pass the traditional typesetting and printing process will find increased use in selected applications. Several forms of electrostatic printing are now undergoing extensive development to increase output speeds and reduce the cost of output copies. Advances in the Xerox and Electrofax processes will begin to affect some company in-house printing operations before 1975. Electrography, such as Varian's Statos V, and ink-jet printing will find increased acceptance as printers for material that would be typeset and printed. In general, electrography and ink-jet printing will be directly interfaced to a computer system.

5 COMPARISON OF PHOTOTYPESETTERS

Second Generation Phototypesetters

Second generation phototypesetters currently being produced and marketed by United States manufacturers are compared in Table 1. Table 2 describes phototypesetters that have been announced, and in some cases demonstrated, by the manufacturers but are not yet in production and ready for general delivery. All expected delivery dates and performance characteristics listed in Table 2 should be considered as tentative until actually achieved.

Second generation devices vary over a broad range of price and performance characteristics. As described in the section on Market Segments, three general groupings can be observed in Tables 1 and 2.

- Units priced below $15,000.
- Units priced between $15,000 and $30,000.
- Units priced between $30,000 and $75,000.

Input

Most second generation phototypesetters are designed to operate from punched paper tape input. Properly formatted paper tapes are generated either by a digital computer or keyboard perforating unit. Direct keyboard entry into the typesetter is slow because the machine is dedicated to the keyboard and controlled by the operator's speed. Since the operator has many manual decisions to make, his output speed is limited. Direct keyboard entry can be an advantage when used for the manual correction of errors while the job is in progress.

Paper tape control of the typesetter offers the advantages of off-line input data preparation utilizing several keyboard perforators. Most of the newer phototypesetters require more than one keyboard perforator to keep the machine fully occupied. Paper tape control also operates the machine at its top efficiency rather than that of the keyboard operator. Those machines capable of accepting magnetic tape input enjoy the same advantages given by paper tape input, plus easier handling and increased speed of data entry. However, magnetic tape mechanisms are significantly more expensive than those for paper tape.

Justification is the process whereby spacing between words of a line is varied to attain a uniform line length. More sophisticated machines may also have the ability to vary character spacing within individual words. Machines with justification capability use a small special purpose computer or mini computer to provide the storage and logic necessary to make appropriate end-of-line decisions. While adding to the expense of the phototypesetter itself, overall system costs may be decreased because: (1) the keyboard operator can concentrate on speed and accuracy rather than end-of-line decisions, (2) inexpensive keyboards without justification circuitry may be purchased, or (3) use of a computer for composition may not be required.

Typographic Characteristics

The typographic characteristics or capabilities of a phototypesetter are a prime factor in the selection and purchase of a unit. The specific capabilities that are normally considered to comprise a machine's typographic versatility include: (1) the number of fonts under automatic tape control, (2)

TABLE 1

SECOND GENERATION PHOTOTYPESETTING

Manufacturer & Model	Input Media[1]	Machine Justification	No. of Fonts Controlled	Characters per Font	Total Characters Available	Point Size Range	No. of Sizes Controlled	Max. Line Length (picas)	Speed (Newspaper Lines/Min.)	Purchase Price ($000)	Application
LOW-PRICED, TEXT											
Compugraphic											
2961	P	Yes	2	90	180	5 to 12	1	33	25	8	Text
2970	P	No	2	90	180	5 to 12	1	33	30	4.5	Text
2971	P	Yes	2	90	180	5 to 12	1	33	25	8	Text
4961	P,K	Yes	4	90	360	5 to 12	1	33	25	11	Text
4962	P	No	4	90	360	5 to 12	1	33	25	5	Text
4971	P,K	Yes	4	90	360	5 to 12	1	33	25	11	Text
Friden											
Justotext 70	P	No	2	90	180	5 to 12	1	33	30	6	Text
LOW-PRICED, VERSATILE											
Alphatype											
Alphatype	M	Yes	10	84	840	6 to 18	1	66	8	17	Text/lim. display
American Type Founders											
ATF B-8	P	No	2	88	176	5 to 14	1	44	9	20	Text
Fairchild Graphic Equip.											
2020	P	Yes	2	108	216	5 to 18	1	30	18	18	Text/lim. display
Photon											
713-Taskmaster	P	Yes	4	96	384	5 to 36	8	45	40	26	Text/display
Varityper											
AM 725	P	Yes (opt.)	3	112	336	6 to 18	1	45	20	22	Text/lim. display
MEDIUM-PRICED, TYPOGRAPHIC											
Fairchild Graphic Equip.											
8100	P, OM	Yes	12	96	1,152	5 to 18	4	30	100	45	Text/lim. display
Harris-Intertype											
1200	P	No	10	120	1,200	5 to 72	19	51	30	67	All purpose
TXT	P, OM	No	4	120	480	5 to 36	12	42	100	50	Text/display
Mergenthaler											
Super Quick	P	No	8	96	768	5 to 72	3	45	40	39	Text/display
Photon											
532	P	No	32	90	2,880	5 to 72	22	54	25	53	All purpose
561	P	No	16	90	1,440	6 to 72	12	54	25	NA	Display/complex text
713-10	P, OM	No	8	96	768	5 to 36	8	45	40	50	Text/display
713-40	P, OM	Yes	4	96	384	5 to 36	8	45	70	68	Text/display
713-100	P, OM	No	8	96	768	5 to 36	8	90	65	60	Text/display

[1]: *P - paper tape; K - direct keyboard; M - magnetic tape; OM - optional magnetic tape*

TABLE 2

PROPOSED SECOND GENERATION PHOTOTYPESETTERS

Manufacturer & Model	Date of First Delivery	Total Char. Available	Point Size Range	No. of Sizes Controlled	Speed (Newspaper Lines/Min)	Purchase Price ($000)
LOW-PRICED, TEXT						
Star Parts						
CompStar	4 Qtr/70	180	5 to 18	1	130	12
VariTyper						
AM 707	1 Qtr/71	200	5 to 18	2	40	12
LOW-PRICED, VERSATILE						
American Type Founders						
Photocomp 20	N.A.	360	5 to 18	1	20	16
Compugraphic						
ACM 9000	1 Qtr/71	816	5 to 72	12	N.A.	Under 20
Fairchild Graphic Equip.						
PTS 4000	3 Qtr/70	216	5 to 18	1	35	23
Friden						
Photomix 70	3 Qtr/70	408	5 to 18	9	30	21
Graphic Systems						
CAT	4 Qtr/70	408	5 to 18	9	50	17
Mergenthaler						
V-I-P	4 Qtr/70	576	6 to 48	16	32	20
MEDIUM-PRICED, TYPOGRAPHIC						
Photon						
713-200	4 Qtr/70	384	5 to 36	8	200	68

the number of characters per font, (3) the range of point or type sizes available, (4) the number of point size settings automatically available under tape control, and (5) the maximum line length that can be typeset. The capabilities of an individual machine are usually a function of the market segment in which it competes. A small complement of characters limited to a single point size restricts use of a machine to job applications requiring virtually no mixing of fonts or type sizes. As the number of fonts and different type sizes automatically available increases, the complexity of jobs that can be economically performed increases proportionately.

Most phototypesetters priced under $15,000 have

achieved their low cost by reducing typographic versatility, including elimination of many automatic features under control of the input tape. A limited complement of characters and type size variations under tape control characterize machines in this market segment. A typical configuration has 180 to 400 individual characters available in a single point size. A change of font or point size requires manual insertion of a new master character set and in some cases the drive gears that advance the output media must also be manually changed.

In contrast, the new hybrid units priced between $15,000 and $30,000 typically hold from 360 to 800 individual characters which can be set automatically in any of 8 to 16 different sizes. Type size variation control through the input tape cannot be made on Fairchild PhotoText Setter (PTS) 2020 and PTS 4000 units. Manual movement of two levers provides type size changes. Machines like Fairchild's might be chosen for applications using only occasional changes of point size, but not those involving frequent changes.

Phototypesetters priced above $30,000 normally provide the broadest typographic capabilities. Most units store from 400 to 1,200 master characters with 4 to 12 type size variations automatically available within the machine. The result is a usable complement of 2,500 to 23,000 characters. The Photon 532 Fontmaster has available under tape control a phenomenal 2,880 master characters in 22 type sizes for a total of 63,360 characters.

The total point size range available from a phototypesetter affects its ability to perform various classes of work. A point size range of 5 to 12 points covers normal newspaper and book text requirements, but excludes work on newspaper displays, newspaper text headings and book headings. Extension to 18 points permits the setting of newspaper headings and most book headings. Newspaper display headings and advertisements require point sizes up to 72 or 96 points to insure full coverage of all applications.

The point size ranges listed in Tables 1 and 2 for machines priced under $15,000 clearly indicate that most of these devices are intended to perform newspaper and book text work. They are best applied to installations that produce large amounts of textual material in fairly rigid formats.

Speed

To achieve the greatest consistency in comparing output speeds of second generation phototypesetters, the standard industry reference measure of newspaper lines per minute was chosen. A newspaper line of text normally consists of 8 or 9 point type in a line 10-1/2 or 11 picas long (6 picas per inch). The figures given in Tables 1 and 2 do not indicate the true productivity of each phototypesetter over an extended period of time because of normal setup, testing, maintenance and other miscellaneous delays that occur during actual operation. However, the figures do give a reasonably accurate comparison of output speed between units within the same market segment. Any machine used for applications intended for more sophisticated equipment will suffer significant reductions in its rate of throughput.

Most of the fastest machines listed in Tables 1 and 2 have only recently been announced by their manufacturers and in many cases there are no actual field installations yet in existence. The ability of these units to achieve the stated goals is still to be proven in a working environment.

Specific Devices – Table 1

A few additional comments about specific second generation phototypesetters listed on Table 1 are given below.

The Alphatype unit, introduced in 1961, was one of the early entries into the photocomposition market. It has no unique capabilities and cannot compete favorably with the fast, inexpensive models now available.

The ATF B-8 of American Type Founders is also an older machine and does not compare favorably with the newer machines in applications that require high-speed output. However, the typographic quality of the output is quite good.

All of Compugraphic's CG 2900 and CG 4900 series of phototypesetters are intended for installa-

tions that produce large amounts of textual material in rigid formats. For this application they are well designed and very attractive in price and performance. The CG 4900 series has twice the typographic capability of the CG 2900 series but is priced approximately $3,000 higher.

Compugraphic has recently announced that increased output speeds and point size ranges are available on some models at an optional cost. A twin lens feature, increasing the point size range to 5 to 24 points, is available on models CG 2961 and CG 2971 for $450 and on Model CG 4961 for $550. Increases in output speed to 60 newspaper lines per minute (lpm) were made available for the CG 2961, formerly a 25 lpm machine, and the CG 4962, formerly a 35 lpm unit. Additional cost for this option is $450 for the CG 2961 and, interestingly, nothing for the CG 4962. These added capabilities further enhance the outstanding utility of Compugraphic's machines.

The Fairchild PhotoTextSetter 2020 is a galley producing phototypesetter which can handle a full range of text sizes. Its general characteristics are average and undistinguished. The PTS 8100 model is a much more powerful machine featuring 1,152 master characters and an announced speed of 100 newspaper lines per minute for high speed text production. At a price of approximately $45,000, the PTS 8100 should be quite competitive if proven reliable during initial field installations.

The JustoText 70 manufactured by the Friden Division of the Singer Company is another of the increasing number of small machines aimed at the market for straight newspaper and book text work. The machine is very similar to the Compugraphic CG 2900 series in basic design except that it cannot accept and compose unjustified input tape. In fact, Compugraphic currently has a patent infringement suit filed against Friden for its design of the JustoText 70. The unit provides little more flexibility than a strike-on typewriter composing unit and is not expected to compete favorably against the Compugraphic models.

The Fototronic 1200 by the Harris-Intertype Corporation was initially manufactured using electron tube circuitry, but now uses transistors, integrated circuits, and plug-in circuit modules similar to competing equipment. The primary strengths of the unit are its typographic versatility and an extensive library of both text and display typefaces that are available from the company.

Harris-Intertype has recently announced a new text-oriented version of the Fototronic 1200, designated the TXT. The unit has good typographic flexibility and speed but seems to be quite expensive when compared to the low-priced hybrid units that will probably form its primary competition.

Mergenthaler's Linofilm Super Quick, introduced in 1968, is no longer the highly competitive machine it was at that time. Newly announced hybrid units, including Mergenthaler's own V-I-P, offer both improved typographic capability and speed at a reduced price. In field installations, the Super Quick is noted for high quality output, but continuing mechanical problems with the complex optical wedge system have plagued the machine.

Photon produces a series of machines that cover a broad range of typesetting applications. One of these is the 532 Fontmaster known as "the total composing room." A master character set of 2,880 characters in 22 different type sizes is the largest character complement ever assembled on one machine. The 532 is described as the first practical phototypesetter capable of composing the Japanese language and one unit was recently installed there.

Photon's most popular series, the 713, presents a broad range of capabilities and prices. The smallest model, the 713 Taskmaster, is priced at the upper end of the low-priced versatile market segment. It competes against the new hybrid units but offers a much greater display capability than most. The typographic flexibility and output speed of the machine are competitive but not outstanding.

The Photon 713 series models 10, 20, 30 and 40 have been popular sales leaders for the company. However, with introduction of the 713 Taskmaster, the 713-100 and 713-200 models, the economic viability of these older models has been greatly reduced.

The VariTyper AM 725 has the performance characteristics of a low-priced text-oriented machine but is sold at a price equivalent to most hybrid units. The AM 725 would be quite attractive if the price were halved.

Specific Devices – Table 2

Additional comments about specific second generation phototypesetters described in Table 2 are given below.

American Type Founders announced the Photocomp 20 several years ago. Since that time several unsuccessful attempts have been made to demonstrate a prototype at trade shows. There are serious doubts about the Photocomp 20 ever reaching the market. If it does reach the market as specified, its price and performance characterisitcs are no longer attractive.

Compugraphic's proposed ACM 9000 series should rate as a very strong contender in the low-priced versatile market segment if the equipment achieves its announced specifications. It combines good typographic flexibility with fully automatic operation at an extremely attractive price. So far Compugraphic has always been right.

The PTS 4000 by Fairchild Graphic Equipment is a revised model of the PTS 2020. The new model doubles the speed of the PTS 2020, from 18 lpm to 35 lpm, but does not have sufficient typographic capability and automatic operating controls to effectively compete with the other hybrid machines.

Friden's new entry, the Photomix 70, has specifications that appear equal to most others in the hybrid market. The unit was designed and is being produced by Graphic Systems, Inc. for Friden. It employs an optical system that uses fiber optics with a unique "image enhancer" technique.

Graphic Systems has announced its own system called the Computer Actuated Typesetter, or CAT. The company is currently looking for a major industry manufacturer to market the device. The unit is exactly the same as Friden's Photomix 70 except that it is a "slave" unit requiring computer-generated input.

The Mergenthaler V-I-P appears to be a very attractive entry into the hybrid or low-priced versatile market segment. Its specifications contain outstanding typographic capabilities for the price. The machine has strong display capabilities but is restricted from unlimited mixing of fonts and type sizes within a line. Any two fonts can be mixed within the line as long as they are of the same point size. Point sizes may vary between lines.

Photon's 713-200 is one of the fastest phototypesetters offered. Its speed plus reduced typographic capabilities make it ideal for high-volume text applications needing some display capability. As listed in Table 2, the 713-200 will set lines 15 inches wide, which makes it applicable to the typesetting of full newspaper pages. At $68,000 this unit should be attractively priced. Another version of the 713-200 is available that sets up to 8-inch lines of type and costs $5,000 less.

The CompStar by Star Parts should be a strong new competitor to the low-priced text-oriented field. The unit has demonstrated outstanding speed, above 130 lpm, for its price of $12,000. Its character complement is very restricted but is similar to that of its competition.

Varityper's AM 707 should also be a highly competitive phototypesetter. It is the only low-priced text machine with two type sizes under control of the input tape. The unit should be ready for delivery during the first quarter of 1971, but the company's former delays in preparing the AM 725 for delivery leave doubt as to the firmness of this date.

Specific Devices – Computer Peripheral Phototypesetter

Photon's recently announced computer peripheral phototypesetter, Model 7700, was not listed in Tables 1 or 2 because of its unique application. Model 7700 is an off-line, magnetic-tape-driven printer that introduces printing typeface designs, typographic character and word spacing, and format flexibility into computer printout. The unit holds and automatically mixes two fonts of 96 characters each in two type sizes. The point size range for the machine is 7 to 18 points, and its

maximum line length is 45 picas or 7.5 inches. Average output speed is 300 lines per minute for a full line of 7.5 inches. Purchase price for the Model 7700 is $70,000, with an optional rental program at $1,500 per month.

Third Generation Devices

There are currently four third-generation cathode ray tube (CRT) phototypesetters being produced and marketed by United States manufacturers. Criteria for comparing and evaluating each machine are listed in Table 3.

Basic Features

All four CRT phototypesetters are designed to operate off-line from computer-generated input. The off-line mode provides greater flexibility in use of the overall computer-phototypesetter system and insures that phototypesetter testing and delays will not use computer time unproductively.

All of the machines except the Linotron 505 use magnetic tape as the input source. The Linotron 505 has an optional magnetic tape capability but was initially designed for use with perforated paper tape. The Linotron 505 also has a keyboard perforating unit that can be used to correct or change copy at the last moment.

Character Storage

The methods currently used to store characters for CRT phototypesetting are digital storage of coded characters and photographic storage of character images on grids. The method of character storage is one of the most crucial areas of machine design as it affects several important machine parameters: (1) size of the available character complement, (2) output speed, and (3) machine cost.

In general, the following relationships hold true.

- Digital storage gives greater character and font availability and flexibility than photographic storage because it is not restricted to the number of images that can be stored mechanically within the machine.
- Digital storage is faster than photographic storage for complex jobs when adequate storage is available on-line within the phototypesetter, i.e., memory discs directly interfaced with the machine.
- Digital storage is more expensive than photographic storage because the system is more complex.

Typographic Flexibility

Typographic flexibility is also affected by the method of character storage. The fixed dot size used with photographic storage systems gives a uniform, high-quality resolution. Size variations are accomplished economically and without the need for operator judgement concerning the type size involved. Digital storage systems which use a varying dot size and stroke width are expensive as complex circuitry is required. They also experience decreased output quality as the dot size increases and number of strokes per inch decreases. The operator must decide what master character size range will give the best resolution for the type size desired.

Area Of Composition

Area of composition defines the output pattern displayed on the face of the display CRT. Three methods are used: stroke, line and page. The stroke method generates each stroke of each character in exactly the same place on the face of the CRT. The line method uses horizontal deflection of the electron beam between each stroke or dot until a line of type is set. The page method is similar to the line method except that it also incorporates vertical deflection of the electron beam to set a complete page of type.

In general, machines that set full pages of type are more expensive than those using the line or stroke method because they require: (1) larger, more expensive CRT tubes, (2) more sophisticated circuitry to overcome distortion, and (3) finer resolution to allow magnification to the desired size.

TABLE 3

THIRD GENERATION CATHODE RAY TUBE PHOTOTYPESETTERS

Description of Comparison Criteria	RCA Video-comp 800	Harris-Intertype Fototronic CRT	Mergenthaler Linotron 505	Mergenthaler Linotron 1010
Mode of Operation	Off-line	Off-line	Off-line	Off-line
Input Media	Magnetic tape	Magnetic tape	Paper tape (opt. magnetic tape)	Magnetic tape
Character Storage				
- Method	Digital	Digital	Photographic	Photographic
- Medium	Core (opt. magnetic disc)	Magnetic disc/drum	Four glass grids	Four glass grids
Character Availability				
- Total	Unlimited	Unlimited	1018	1024
- Without time loss	480 (larger with opt. magnetic disc)	4096	302	256
- Time loss for font change	1 sec.	20 sec. (seldom req'd)	1 sec.	0.5 sec.
Point Size				
- Range	4 to 96	4 to 24	4 to 72	5 to 18
- Variations/master char.	8	11	20	8
Method of Char. Generation	Vertical strokes	Matrix of dots	Vertical strokes	Electronic cloud
Area of Composition	Line (opt. page)	Line	Stroke	Page
Maximum Line Length	70 picas	69 picas (opt. 100)	60 picas	49 picas
Reverse Leading	No	Yes	Yes	Not required
Resolution				
- Lowest	900 lines/inch	512 lines/inch	650 lines/inch	278 lines/inch *
- Highest	1800 lines/inch	1200 lines/inch	1300 lines/inch	832 lines/inch
Speed				
- Straight Text	1043 pages/hour	962 pages/hour	160 pages/hour	835 pages/hour
- Directory	177 pages/hour	400 pages/hour	62 pages/hour	360 pages/hour
- Telephone Book	227 pages/hour	173 pages/hour	28 pages/hour	163 pages/hour
Special Features	Opt. microfilm output	Opt. microfilm output		
Purchase Price/Rental				
- Basic Unit	$341,775/$8,100	$322,500/$8,700	$111,550	$400,000/$10,315
- Basic Software	Standard ($400/month for IBM 360)	$25,000 - Pagatext $40,000 - HCS	Standard	Standard
- Magnetic Tape Reader	Standard	Standard	$26,500	Standard
- Additional Memory	$38,250/$850 (32K core) $32,710/$750 (disc)	$22,500/$600 (per 256 character disc)	N.A.	N.A.
- Full page composition	$10,200/$225			
- Microfilm	$9,600/$225	By quotation		

* (proof mode)

Conversely, the ability to set complete pages of type increases both the speed and flexibility of a machine's output. Speed is gained because electronic deflection of the electron beam to a new line is significantly faster than a mechanical film advance. Flexibility is increased because multi-column work can be set one column at a time rather than a line at a time across all columns. In this particular application, the computer programs required are less complex and actually reduce time demands on the host computer.

Output Speed

In determining the output speed for each phototypesetter, the manufacturer's stated maximum rate of output did not provide a consistent base for comparison and did not take into account time delays for font loading, film advances and other miscellaneous tasks. In a report titled *Report on Cathode Ray Tube Character Generation Devices* prepared for Printing Industries of America, Incorporated, estimates of the time required to set eight sample pages of varying complexity were made for each CRT phototypesetter. The estimates were made given the following set of guidelines:

- Standard operating conditions.
- Standard fonts unless otherwise noted.
- Minimum resolution of 600 lines per inch.
- Time for interline leading (film advance) to be included.
- Time for leading between pages to be included.
- Setup time or materials handling time not to be included.

To compare the capabilities of the four phototypesetters in Table 3, CSI chose the results from three of the eight samples. The first example measures a page of straight text material requiring only one point size, one font and two italicized words. The second example measures a directory of medium difficulty requiring two columns, two fonts, five type sizes from 8 to 36 point and minimum use of italics. The final example is a telephone directory requiring four columns, three fonts and two point sizes.

While Table 3 does present reasonably accurate output speeds for comparison, these figures do not indicate the true productivity of a phototypesetting system. Delays for tape loading, film loading, film processing, job setup, maintenance requirements and other tasks differ significantly from machine to machine and installation to installation. The effect of these delays is to reduce significantly the advantage of the higher speed phototypesetters over a long period of time.

Price

Purchase prices have remained fairly stable over the past several years with most variations coming from the addition of optional features. As with most capital acquisitions of this size, rental arrangements are very important. RCA was the first manufacturer to offer a rental program and its success has now forced all manufacturers into offering similar programs.

Support Services

Another area of comparison not listed in Table 3, because of the difficulty in quantifying it, is support services. RCA has been treating the Videocomp as part of a computer system ever since the machine was introduced. In so doing, they have been working hard at developing software support, field service support and a significant font library. RCA currently has a significant lead in these areas over both Harris-Intertype and Mergenthaler. However, both Harris and Mergenthaler have recognized the need for a systems concept and are working very hard to overtake RCA.

Specific Devices

Additional comments about specific CRT phototypesetters are given below.

The RCA Videocomp 800 series is the latest upgrade for the basic Videocomp line. With the 800 series RCA has made available options which add new perspective to its product. A new full-face writing option provides for composition of a 7 x 9

inch (42 x 54 picas) page without advancing the output media. While the page size is somewhat small, the overall effect of this option is an increase in the output speed and versatility of the Videocomp.

The second option of major importance is the availability of a disc storage unit directly interfaced with the Videocomp that provides additional storage capacity of 7.25 million 8-bit bytes. Use of this option greatly reduces the necessity of frequent loading of new fonts into the Videocomp memory and eliminates one of the most serious drawbacks to the older Videocomps.

Additional features such as a line drawing option and an ability to rotate the typeset image 90^{o} extend the applicability of the Videocomp into the typesetting of catalogs, maintenance manuals, engineering drawings and similar items. These features, while important, are not as significant as the full-face writing and disc storage options.

Harris-Intertype's Fototronic CRT was the most versatile phototypesetting device on the market before RCA announced its new options. It is still as flexible as the Videocomp, lacking certain Videocomp capabilities—such as full page composition—but having abilities the Videocomp lacks—such as reverse leading. The company's main problems still remain in the area of service support. It is of interest to note that Harris is the only manufacturer that charges for its basic software packages.

Mergenthaler's Linotron 505 is unique in that it is a CRT phototypesetting device but it does not compete directly with the other third-generation devices. It is designed to penetrate a hole in the market between the current second-generation phototypesetters and the other CRT devices just discussed. The Linotron 505 is the only CRT device produced in the United States that also meets the price and performance requirements of the European market.

The Mergenthaler Linotron 1010 was designed and built primarily for the Government Printing Office. It is potentially the most powerful of all the CRT phototypesetters built, but it is practically limited by the flexibility of its character complement and its 8-1/2 x 10 inch maximum page size. The Linotron 1010 is also the most expensive of all the third-generation phototypesetters. The lease price to the Government Printing Office, including on-site maintenance service, is 30 to 40 percent higher than normally found for Videocomp or Fototronic CRT installations.

6 COMPETITION

Competition within the phototypesetting market varies significantly among individual segments. The announcement of new products is occurring at a rapid rate in both the low-cost text and the low-cost versatile market segments. By the end of 1970 competition within these segments will be quite sharp. Conversely, there presently is no competition within the medium-priced electronic market segment as the Mergenthaler Linotron 505 is the only device available. This is considered a temporary situation as several firms are reportedly developing competing phototypesetters. CSI anticipates that at least one, and more likely two, additional products will make this market segment highly competitive within two years. Both the medium-cost typographic and high-cost electronic market segments have significant competition and are expected to change very little.

An interesting recent development is the increased competition among products in different market segments. Until two to three years ago, the medium-priced typographic and high-priced electronic were the only market segments with significant product selection. Development of the three new segments has both opened up new markets by offering a much broader range of products and drawn off sales from existing segments.

Competitive Factors

Within the typesetting industry, machine design and performance characteristics are important. The units of production (printers, publishers and typesetters) within the industry are very fragmented and exhibit a profuse range of requirements. As a result, each user is looking for the machine which will best suit his special set of needs.

Price is also a significant competitive factor. Because the typesetting industry is so fragmented, there are many small shops fiercely competing for business. Operating margins are consequently thin and minimum production costs are required to make a profit.

In the larger printing, publishing and typesetting establishments, loyalty to a particular manufacturer often influences the purchase decision. Shops that have used Mergenthaler Linotypes for years will automatically turn to Mergenthaler when the decision is made to use photocomposition. This loyalty normally is related only to the older manufacturers who have been associated with the industry for years. The radical changes currently being experienced by the industry are gradually decreasing the significance of this competitive factor.

The availability of typeface styles and selection also influences the purchase decision. It is one of the reasons for manufacturer loyalty mentioned above. Buyers normally want a broad selection of typefaces available and they want those which they have been using for years. For this reason, manufacturers of hot metal linecasters like Mergenthaler and Harris have a marketing advantage that results from their large font libraries established over many years and a large number of users accustomed to their font styles.

Systems support has yet to become a significant competitive factor in the sale of second generation machines because none of the manufacturers have adequately provided support. Most programming and systems work has been left to the customer or service bureaus opened to fill this gap. In the sale of third generation CRT phototypesetters, systems support is much more critical because a computer is integral to the system. Part of RCA's initial suc-

cess can be attributed to its computer-oriented systems approach. Harris and Mergenthaler, historically using a hardware approach, have found that outstanding hardware is not sufficient in a computer-based system unless good programs are available to run it effectively.

Product Development

Development costs for a phototypesetter prototype vary among market segments. For a low-priced text machine, development would normally cost less than one million dollars. Costs for the larger low-priced versatile and medium-priced typographic machines range from one to two million dollars if the concept is a new one, and considerably under one million dollars if it is simply a variation of an existing device. Development costs for a CRT phototypesetter range from two to over five million dollars depending on its size and capabilities.

As is true for other similar industries, marketing can be the most significant cost factor in development and sales of a new product. Small companies can normally develop prototypes more cheaply and faster than large companies, but cannot afford to cover the market in sufficient volume to generate the required sales volume. The answer is often an OEM sales agreement or merger into a larger company that has a large sales staff already established.

Companies

Alphatype

Alphatype is a publicly-held company based in Illinois. It was one of the early manufacturers of phototypesetters, having introduced its initial product in 1961. The unit, which is priced in the low-cost versatile market segment, has good display capabilities and is used a great deal in connection with the advertising industry. Even with a new expanded font capability, the machine is out of date and CSI does not expect significant long-term sales. It is rumored that the company is preparing a competitive product for the low-priced sector of the market. Practically all of the company's $2.7 million sales during 1969 were from typesetting products.

American Type Founders

American Type Founders (ATF) is a subsidiary of White Consolidated Industries, a New York Stock Exchange company. Sales of phototypesetters by ATF is an insignificant portion of the parent company's 1969 sales of $768 million. ATF, like Alphatype, is one of the early manufacturers of phototypesetters. The company has not undertaken extensive new product development and its model ATF B-8 is no longer highly competitive within the low-priced versatile market segment. Unless new products are introduced, CSI does not expect ATF to be an important participant in the future market for phototypesetters.

Compugraphic Corporation

Compugraphic Corporation is a Massachusetts company that went public in March, 1970. Sales of phototypesetters constitute approximately 85 percent of current revenues with special-purpose typesetting computers repsonsible for the remainder. The company expects this balance to shift even more toward phototypesetters in the future.

Compugraphic must be considered as one of the most successful ventures in phototypesetting. In 1968 the company, then the leading manufacturer of special-purpose typesetting computers, introduced a series of inexpensive photocomposition devices aimed directly toward text typesetting applications dominated by strike-on devices. The results of this move have propelled Compugraphic to industry leadership in the number of units sold annually, although not in revenues, and has caused significant erosion within the cold type industry.

The company's products are simple, reliable units providing reasonable, and in some cases good, performance within restricted formats. They are priced from $4,500 to $12,000, including a spare parts kit, and are designed for applications requiring minimal font mixing and text size variations. At Compugraphic's low prices, the number of users with these requirements is very large. A proliferation of new product announcements will increase competition within the market, but CSI expects Compugraphic to maintain a strong leadership position.

The company has also announced a new series of machines, the ACM 9000 series, which should participate in the low-cost versatile market segment. CSI expects the company to attain a strong position within this segment but not one of leadership because:

- New sales and marketing techniques must be learned to deal with a user group unfamiliar to the company.

- Other strong manufacturers are established or will be established prior to entry of the ACM 9000 in the first quarter of 1971.

Fairchild Graphic Equipment

Fairchild Graphic Equipment is a division of Fairchild Camera and Instrument Corporation, a New York Stock Exchange company. Sales of phototypesetters by the graphic equipment division is an insignificant portion of the parent company's 1969 sales of $251 million. This relationship is not expected to change through 1975. Fairchild has recently gained a reputation for announcing uncompetitive equipment to the market and then announcing a superseding product before significant, if any, sales of the original product are made. Fairchild is now marketing the PTS 2020 and PTS 8100 phototypesetters. The PTS 8100 is a reasonably competitive machine within the medium-priced typographic market, but the PTS 2020 is undistinguished in the low-priced versatile market. The PTS 2020 is scheduled to be superseded by the new PTS Syncro/Set 4000 which offers higher output speed but no other substantial advantages over the PTS 2020. CSI does not look for Fairchild to be a major factor in the phototypesetting market.

Friden

Friden is a division of the Singer Company that had sales of $1.9 billion in 1969. Revenue from sales of phototypesetters by Friden was extremely small in 1969. Friden has recently announced three new products. The Justotext 70 competes in the low-priced text market segment and costs $6,000. The Photomix 70 is a $21,000 device competing in the low-priced versatile segment. The third product, Photo Display 70, is a display machine not designed for text work.

CSI does not expect Friden to have a major impact on the total phototypesetting market. The Photomix 70 is an attractive machine and should do well in its market segment, but the Justotext 70 is not expected to do as well. During 1970 and '71, former relationships with Justowriter customers should generate good sales, but the machine, which provides little more flexibility than a typewriter, is then expected to encounter a sharp sales decline as more competitive equipment becomes available.

Graphic Systems, Incorporated

Graphic Systems is a new privately-held venture just entering the phototypesetting field. The company designed and is manufacturing the Photomix 70 for Friden on an OEM basis, but has maintained the right to manufacture and sell a similar machine, accepting only computer-generated input, under the Graphic Systems name. Delivery of the new machine is expected during the last quarter of this year. Sales projections for this phototypesetter have not been made because marketing arrangements for sale of the product have yet to be determined.

Harris-Intertype Corporation

Harris-Intertype Corporation is a New York Stock Exchange company that had revenues of $339 million during fiscal 1969. Harris is a major supplier to the printing and publishing industry with over $200 million of 1969 revenues coming from the sale of printing presses, phototypesetters, hot metal linecasters, and other related products. Sales of phototypesetters are estimated at $3.8 million for 1969 but should climb significantly to about $10.5 million in 1975.

The Intertype Division of Harris sells phototypesetting products to the medium-priced typographic market segment and the high-priced electronic segment. Harris' products in the medium-priced market have typically been high-quality expensive machines. Although the present Fototronic TXT model is overpriced when compared against competing equipment, the company continues to sell machines based on close relationships with former users of Harris' hot metal linecasters.

The Harris Fototronic CRT is also a high-quality machine and it is competitively priced. The Harris CRT phototypesetter was the most flexible CRT device and had the best performance characteristics of any on the market until RCA announced a new series of options for the Videocomp. It is still a highly competitive machine. The company's initial problem was its hardware orientation. Only recently has the company moved to provide adequate systems and service support together with a reasonable machine rental program. Within several years, CSI expects Harris to approach RCA in systems support and to start closing the sales gap between it and RCA.

Harris also has two interesting phototypesetters in development. During 1969 the company purchased 50 percent of Purdy & McIntosch Ltd., an English firm primarily concerned with phototypesetting equipment development. Two machines Purdy & McIntosch have well into development are a medium-priced CRT phototypesetter to compete with the Linotron 505 and an inexpensive device to compete with Compugraphic. If both of these machines are brought to fruition, Harris would enter two market segments it does not now serve and could do significantly better than CSI's projected sales level of $10.5 million in 1975.

Mergenthaler Linotype Company

Mergenthaler was started by Ottmar Mergenthaler who invented the Linotype, the original hot metal typesetting machine, in 1885. Mergenthaler is now a subsidiary of Eltra Corporation, a New York Stock Exchange company. Mergenthaler's estimated 1969 revenues of approximately $12 million are 3 percent of the parent company's total 1969 revenues of $432 million.

Mergenthaler enjoys the strongest manufacturer loyalty within the industry. Most new products brought out by the company have received good initial acceptance, at least partially attributable to loyalty toward the company. Mergenthaler's primary product at present is the Linotron 505 which was developed for the company by Purdy & McIntosch. Sales response to the machine has been excellent because it fulfills a demand that had been unsatisfied by second generation or high-priced CRT units. Performance characteristics of the machine are good but are subject to improvement by competitors. CSI antiticpates that Mergenthaler will be forced to upgrade the machine continually over the next several years or face sales losses to increasingly competitive new entries.

Mergenthaler's other principal product, the Linofilm Super Quick, is no longer highly competitive. The company has developed a replacement for the Super Quick called the V-I-P. It is a $20,000 machine aimed at the low-priced versatile market segment. CSI expects the V-I-P to do very well within that segment and become one of the market leaders.

Photon Incorporated

Photon is a publicly-held Massachusetts company that derived virtually all of its 1969 revenues of $18 million from sales of phototypesetting and related products. Photon has been the industry sales leader for many years and is expected to maintain that position through 1975.

For years Photon has presented the broadest product line in the phototypesetting industry. Many individual arrangements were available from two or three general configurations. Photon is maintaining this successful format and while not directly providing products in all market segments, the company does present a strong complement of products.

Possibly the most exciting product is the newly announced Model 7700, a phototypesetting peripheral computer output printer. The unit is capable of printing, with typographic quality, 300 lines per minute of computer generated output. It is designed to supplement a computer line printer where high-quality output is wanted together with the compaction of variable space typesetting. While Photon's estimates of 5,000 leased units within five years seem optimistic, CSI forecasts that sales of the 7700 will maintain Photon's position of industry leadership.

Photon's strong product line in the medium-priced typographic market segment should give the company dominance over that segment. Even though the company has announced its intention to avoid

marketing products priced below $20,000, it is strongly participating in the low-priced market through manufacture of the AM 725 for VariTyper on an OEM contract.

RCA Graphic Systems

RCA is a New York Stock Exchange company that had sales of $3.2 billion in 1969. Sales of phototypesetters by the graphic systems division accounted for less than 1 percent of total corporate sales. Sales or rentals of RCA Spectra 70 computers in connection with phototypesetting equipment also have minor impact on total corporate sales

RCA's original CRT phototypesetter was designed in West Germany by Dr. Rudolph Hell and named the Digiset. Dr. Hell sold the rights for marketing the machine in the United States to RCA, but maintained the worldwide rights for his own company. RCA uses the name Videocomp for the United States product. RCA has continued to improve the machine and today it offers more capabilities than any other on the market, although many of these are extra-cost options.

RCA is unquestionably the leader in the high-priced electronic market segment and should maintain leadership through 1975. RCA's strong systems orientation due to its computer experience and marketing know-how contributed strongly to its early leadership. During its initial marketing of the Videocomp, RCA would not sell or rent a machine with any computer other than a Spectra 70. Approximately one year ago the company lifted this restrictive policy and now has software available, at a premium, for IBM 360 systems.

Star Parts

Star Parts is a recently acquired subsidiary of Data Scan, a publicly-held company. Star Parts has sold to the typesetting industry for years but is introducing its first phototypesetter, the CompStar. A $12,000 machine, the CompStar will compete in the low-priced text market segment. If the machine operates as well in field installations as it did at a recent demonstration, it is expected to have a strong impact on that market segment. The machine exhibits outstanding output speed for the price.

VariTyper Corporation

VariTyper is a subsidiary of the Addressograph-Multigraph Corporation, a New York Stock Exchange company. The parent company's revenues during 1969 were $416 million of which less than 1 percent was contributed by sales of phototypesetters.

VariTyper is currently marketing a $20,000 phototypesetter, the AM 725, in the low-priced versatile market segment. The machine does not have outstanding characteristics, but the strength of a 500-man Addressograph-Multigraph sales force together with the lack of competition in this new market gave the company estimated 1969 sales of 100 units. A new machine, the AM 707, has recently been announced by the company. If field installations validate the manufacturer's claims, the machine should be very competitive at $12,000. The AM 707 was designed by Photon but is being manufactured and sold by VariTyper. CSI predicts that the AM 707 will have a strong impact on the low-priced text market and that the AM 725 will lose its current strong position in its market segment by 1975.